● *Through the medium of specialized skill and highly developed equipment in the servicing of oil wells, Halliburton service men help to safeguard our supply of* **OIL**—*the priceless commodity that powers and lubricates our entire war machine . . .*

HALLIBURTON OIL WELL CEMENTING CO. DUNCAN, OKLA.

Dual Completions

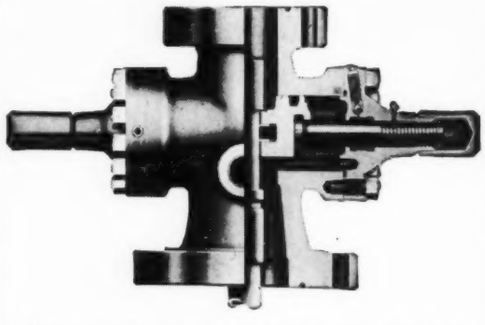
The Cameron Closed Pressure Method of Well Completion which has been employed successfully wherever well pressures present a menace to safe completions has also demonstrated its advantages in pressure maintenance projects where it is desirable to produce from two or more sands or to inject residue gas into two or more formations through a single well bore.

Throughout the entire dual completion operations—gun perforating, washing the well clean, collapsing the packer and suspending the tubing—the Cameron Ram-type Tubing Control Heads and auxiliary Cameron service units provide the ultimate in safe, dependable control.

The Cameron Type "G" Circulating Anchor Packer has been widely used in dually completed wells to assure a pressure tight seal between the producing zones. The unique feature of this rugged packer is the *self-feeding* packing element in the circulating by-pass which assures a pressure tight seal even though the seat may have been cut during washing operations.

The Lewis Transfer Valve, manufactured by Cameron under exclusive license from James O. Lewis, was designed especially for pressure maintenance service. It automatically prevents either of the zones from "loading up" with distillate.

To operators contemplating the need for either dual production or injection wells Cameron issues an invitation to make use of its engineering knowledge gained and equipment perfected through pioneering this method of well completion.



This cross-section view of the Cameron Type "LD" Ram-type Tubing Control Head clearly shows its unique mechanical features. Equipped with rams similar to those of the famous Cameron Blowout Preventer and with patented self-feeding ram packers, this head provides positive protection against loss of control during every stage of completion operations. Hanger nipple type suspension on the closed rams is illustrated, however several other types of suspension are also available.

CAMERON IRON WORKS, INC.
711 MILBY STREET HOUSTON, TEXAS

Export: 74 Trinity Place, New York, N. Y.
California: The Howard Supply Co., Los Angeles
Rocky Mountain: Mountain Sales and Service, Casper, Wyo.

CAMERON IRON WORKS — OIL WELL SPECIALTIES

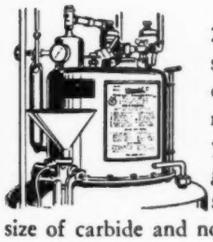
CAMERON-IZE FOR MAXIMUM SAFETY EVERY INCH OF THE WAY

Things you should know about Calcium Carbide

. . . to get the most generated acetylene at Least cost

1. Anticipate your requirements of Union Carbide. This will help assure continued

availability of adequate amounts of carbide where needed.



2. Always order the size of carbide recommended by the manufacturer of your generator. The generator is designed to use that size of carbide and no other size should be used.

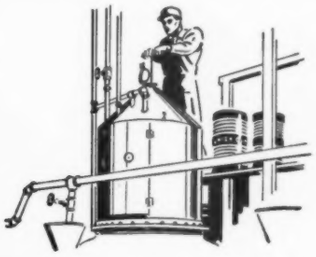
3. Do not open a drum of carbide until you are ready to use it. Calcium carbide keeps indefinitely if kept from the air. If carbide is exposed to the air, you may lose some of the gas.

4. When recharging, always drain and flush the generating chamber, and put in clean, cool water to the correct level, before charging with carbide.

5. When you charge your generator, use a filling funnel to avoid spilling carbide. Do not pack or ram the carbide into the hopper of the generator or it will not feed properly during operation.

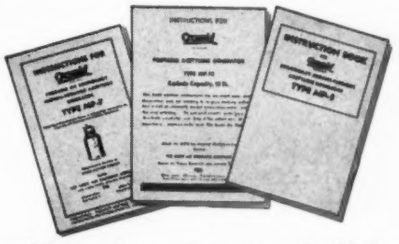
6. Always tightly replace the cover over the gasket on partially full drums. When you open a Union Carbide drum, be careful not to spoil the gasket.

7. Keep your generator clean and in good working order. Follow the main-



tenance instructions furnished by the manufacturer of the generator.

8. Duplicate copies of the operating instruction books supplied with Oxweld generators of all sizes and types can be obtained from any Linde sales office,



without charge. Operators should become familiar with all instructions before operating any generator.

9. Carbide residue can be used profitably. If you would like to know how, write to any Linde sales office for the booklet, "The Utility of Carbide Residue."

Acetylene generators are more important today than ever before because they free acetylene cylinders for vital war work where generators are not readily available. Small portable generators should be used where operations are intermittent, where consumption is small, or where work is done in the field. Stationary generators of greater capacity are recommended where a continuous supply of gas is needed, or where consumption is large. Oxweld generators are made in several sizes providing a range of maximum generating capacities of from 30 to 6,000 cu. ft. of acetylene per hour. Union Carbide is readily available from 245 warehouse stocks, and also through numerous authorized re-sellers located in all parts of the country.

The words "Linde," "Oxweld," and "Union" are trade-marks.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York, N. Y. UCC Offices in Principal Cities

In Canada: Dominion Oxygen Company, Limited, Toronto

You Can Obtain Copies of this Advertisement For Distribution in Your Shops . . . or to Post on Your Bulletin Boards . . . Upon Request.

February, 1943

THE Petroleum Engineer

VOL. XIV NO. 5

THE PETROLEUM ENGINEER PUBLISHING CO. . . . Phone: Central-4571 . . . Seventh Floor Allen Building . . . DALLAS, TEXAS

Clarence Morris, President, 1929-40

A Magazine of Methods for Operating Men

EXECUTIVE

W. L. LOVE
President

W. T. BRYAN
General Manager and Treasurer

EDITORIAL

K. C. SCLATER
Vice-President and Editor

FRANK H. LOVE
Managing Editor

C. C. PRYOR
Associate Editor

WALLACE A. SAWDON
Pacific Coast and Foreign Editor
2062 Paramount Drive
Los Angeles, California
Telephone: HI llside 1695

ADVERTISING

T. J. CROWLEY
Vice-Pres. and Advertising Mgr.

NEW YORK, N. Y.

ROGER MOTHERAL
7545 Kessel Street
Forest Hills, Long Island, N. Y.
Telephone: BOulevard 8-2959

CHICAGO, ILL.

E. V. PERKINS
330 South Wells Street
Telephone: HARrison 1843

LOS ANGELES, CALIF.

R. C. WIPPERMAN
518 North Sweetzer
Telephone: Webster 9617

CIRCULATION

C. R. BARRETT
Circulation Manager

C O N T E N T S

DRILLING AND PRODUCTION — *Page*

Drawworks of Improved Design for Slim-Hole Rig — 29
By C. C. PRYOR

Standard Drilling Equipment Adapted to Marine Operation — 33
By WALLACE A. SAWDON

Recent Developments in Formation Logging (Part 1) — 63
By LESTER C. UREN

Bottom-Hole Choke Combines Automatic Safety Valve — 78
By JOHN O. FARMER

Gun-Perforation of Tubing — 84
By WALLACE A. SAWDON

Casting Lugs on Ends of Wire Rope — 111
By C. R. HOCHMUTH

Effecting Greater Recovery of Well Casing — 133
By F. R. COZZENS

REFINING AND NATURAL GASOLINE MANUFACTURE

Welded Steel Tube For Condensers and Heat Exchangers — 35
By A. F. ZOLL

Hydrocarbons in Petroleum — 41
By FREDERICK D. ROSSINI

Certain Aspects of Cooling Tower Design and Operation (Part 1) — 72
By R. C. KELLY

Vapor-Pressure Chart For Volatile Hydrocarbons — 88
By R. VINCENT SMITH

Refinery Practice for the Operating Man (Vocational Class Proceedings in Refinery Engineering) — 94

OIL AND GAS TRANSPORTATION

Features of New Lone Star Compressor Station — 101
By FRANK H. LOVE

Calculation of Orifice Meter Coefficients — 105
By W. J. BERCHER

GENERAL

Extending Life of Multiple V-Belt Drives — 76

General Advance in Crude Oil Prices Ruled Unjustified — 141

Clarification Crude Oil Prices — 141

Priority Assistance for Materials Abroad — 141

New Natural Gas Wells Kansas, Oklahoma Panhandle Banned — 141

P-98-b Amended—Higher Ratings Assigned — 142

REGULAR FEATURES

	Page		*Page*
The Course of Oil	16	*The Petroleum Engineer's* Continuous Tables (Installment No. 68)	117
Highlights in Oildom	18	Machinery and Equipment	134, 136, and 137
Major Refining Activities	20	From Washington	141 and 142
Major Oil Field Activities	22	Trade Literature	152 and 153
Petroleum Statistics and Field Operations	24	Book Reviews	154
Major Pipe Line Activities	26	Meetings	155
Running Tour With Men in the Industry	112 and 113		
Laugh With Barney	114		

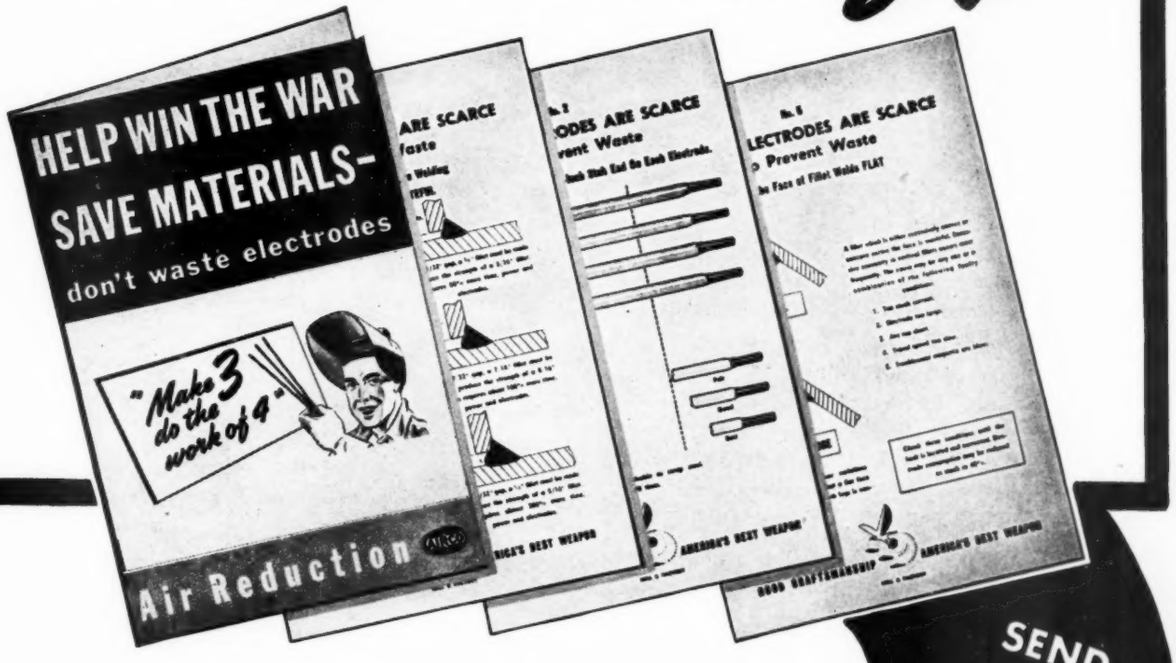
NOTE: Strict government censorship makes it necessary to omit definite locations of refineries, pipe lines, etc., from editorial matter.

MEMBER A. B. C.—A. B. P. (The articles in *The Petroleum Engineer* are indexed in the *Industrial Arts Index*, New York.

Copyright 1943, by The Petroleum Engineer Publishing Company

NEW SHOP BULLETINS

tell how 3 Electrodes can do the work of 4



SEND FOR YOUR COPIES *Today!*

Help your welding operators get the most out of every available electrode by eliminating all possible waste — that's the job that this new folder of shop bulletins will help accomplish. The folder contains a series of six posters, each stressing a waste eliminating "do" or "don't". *Clip the coupon today—and be sure to indicate how many copies you can profitably use.*

AIR REDUCTION

60 EAST 42nd STREET, NEW YORK, N. Y.

In Texas: Magnolia-Airco Gas Products Co.

AIR REDUCTION SALES CO., 60 East 42nd Street, New York, N. Y.

Please send my free copies of your electrode waste bulletins "Help Win the War—Save Materials—don't waste electrodes."

Check number of copies desired.

NAME.....

POSITION.....

COMPANY.....

ADDRESS.....

CITY..... STATE.....

ABLE CYLINDERS ARE PRODUCTION SLACKERS: KEEP 'EM ROLLING FOR VICTORY!

The Course of Oil

by K. C. SCLATER

NATIONAL THREAT IGNORED

A lengthy statement by the Office of Price Administration on February 1 to the effect that a general advance in the price of crude oil is not justified at this time, came as a jolt to the oil industry. If the statement is based—as it appears to be—on the results of a survey made by the Tariff Commission for the OPA on the cost of producing crude petroleum in the United States, the statement is all the more astounding, for that survey covers a period ending the third quarter of 1941, but does not apply to current conditions.

To remove the threat of an impending shortage of crude petroleum in the United S ates *is the paramount problem*. Evidence of such impending shortage is overwhelming. Factual records of operations for 1942 show that efforts to increase crude oil reserves have failed.

It is the experience of the industry that price is a dominant factor in stimulating the discovery of oil. But despite all factual evidence justifying higher crude prices, the Office of Price Administration, judging by its recent statement, still continues to dally over the question of a price increase, obs inately refusing to recognize the imperative need of granting one.

On an increase in price, the P.I.W.C. Committee on Price and Cost Adjustment reports that:

"At the current rate of production, 1.4 billion barrels annually, a 25-cents per-barrel increase in the price of crude would add $350 million a year to the cost of providing the nation's oil supply. It will be shown how small this sum is compared to the cost of prolonging the war.

"$350 million a year—less than one million dollars a day—in absolute terms seems like a huge amount of money. But compare it with the cost of war. For the fiscal year ending June 30, 1943, war activities alone will cost about $74 billion or nearly $203 million every day. However, there is little logical basis for expecting war to end before June 30, 1943. For the year ending June 30, 1944, war activities alone are budgeted at a cost of $97 billion or a little more than $260 million a day, so that for every day the war may be prolonged for lack of petroleum, the people of the United States would have to pay $260 million.

"In other words, every 32 hours and 20 minutes during the coming year, the people of the United States will pay as much to wage war as they would have to pay additionally for a full year's production of crude oil at the current rate if a price increase of 25 cents a barrel became effective. From a simple dollars and cents standpoint, can the United States afford to be penny wise and dollar foolish? Can this nation afford to save a million dollars a day during 1943 at the risk of losing $260 million a day during 1944 or an even larger daily sum during some later year?"

PRODUCTIVE CAPACITY LIMITED

Lest there be any doubt regarding the dire national necessity for increasing crude oil reserves, the following pointed observations of the Committee should be noted:

"Examination of the estimated supply and demand data for 1943, 1944, and 1945, as shown in the following table, definitely indicates that a shortage of crude oil supply is imminent.

	Annual average maximum efficient productive capacity from known fields	*Annual average minimum essential demands*
	(Barrels per day)	
1943	4,421,500	4,100,000
1944	4,212,000	4,400,000
1945	4,022,500	4,400,000

"It must be distinctly borne in mind that the figures indicating productive capacity represent maximum production available from known fields, and do not take into consideration any oil that might be found through new discoveries. Also, the essential demand figures shown above represent minimum demands for crude oil known at this time, and military developments, as pointed out above, could materially increase these demands.

"From the above table it will be noted that without figuring any margin of safety whatever, the shortage for the year 1944 will average 198,000 barrels per day, and that for the year 1945 will average 397,500 barrels per day. These shortages do not provide for any safety factor, or for production from any newly discovered fields.

"This additional ability to produce is roughly divided into: 25,000 barrels per day in the Louisiana Gulf Coast district; 200,000 barrels per day in the Texas Gulf Coast district; approximately 60,000 barrels per day in the so-called Corpus Christi district of Texas; and approximately 215,000 barrels per day in the West Texas-New Mexico district.

"While there is an excess capacity to produce of some 500,000 barrels per day, over and above present production, very little of this excess is available for processing, because either of lack of transportation to the refineries, or of lack of transportation away from the refineries. Furthermore, in the case of the additional ability to produce in the West Texas-New Mexico district, even though transportation was provided to refining centers, certain additional refining facilities would have to be provided to handle the full amount of this additional ability to produce, because of the character of the oil. There are no transportation facilities to take crude into District No. 2 to overcome the estimated decline in production from presently known fields in that district, of approximately 100,000 barrels per day. It is generally agreed that new discoveries in District No. 2 will not compensate for this decline in production."

OTIS PRESSURE CONTROL SERVICE - EQUIPMENT

Sub-Surface Facts

OTIS PRESSURE CONTROL SERVICE - EQUIPMENT

No. 1 | 1943 | DALLAS, TEXAS

EXCLUSIVE LOCKING MECHANISM FEATURED ON ALL OTIS SUB-SURFACE TOOLS...

The locking mechanism is an exclusive feature on all Otis Removable Bottom Hole Regulators, B Chokes and Safety Valves. It is this positive locking device that permits Otis tools to be run and pulled under pressure on a steel line. The locking mechanism is composed of slips and slip carrier attached to a tapered mandrel. The running tool is removably attached to the slip carrier and holds the slips in a retracted position while the tool is being run.

The choke is set at any depth by manipulation of the steel line, stem and jars which drive the slips down over the tapered mandrel and engage the tubing walls in a positive grip. The running tools are released by the impact of the jars and are removed from the hole leaving the choke securely locked in place.

When pulling the choke, a pulling tool on the same steel line equipment is used to unlock the slips by jarring the mandrel downward.

REDUCES SWABBING OF HEADING WELLS *installation of Otis Type B Choke prolongs flowing life*

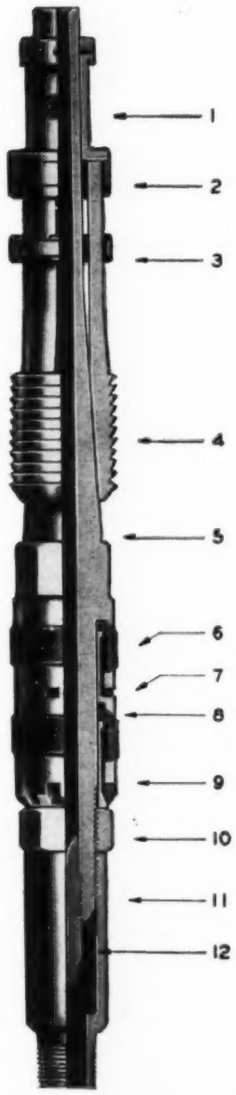
Otis Type B Chokes are being successfully used to extend the flowing life of the weak wells that are flowing by heads and require frequent swabbing to "kick" them off. This is particularly true if the oil still carries a fair amount of gas in solution.

By choking the well at the bottom of the hole, the gas is released from solution, the fluid column is lightened and velocity in the lower end of the tubing is increased.

There are many case histories showing wells that formerly loaded up at freqent intervals were made to flow again for a year or more by the installation of an Otis Type B Bottom Hole Choke.

ELIMINATE SURFACE FREEZING WITH AN OTIS TYPE B REMOVABLE BOTTOM HOLE CHOKE

1. Slip Carrier
2. Slip Carrier Band
3. Mandrel Band
4. Slips
5. Mandrel
6. Otis Sealing Cup
7. Upper Sealing Cup Ring
8. Cup Ring Packing
9. Lower Sealing Cup Ring
10. Cup Nut
11. Screw Bean Cage
12. Screw Bean



TUBING ACTS AS A "MILE LONG" HEAT EXCHANGER

Freezing of surface connections is positively eliminated by bottom hole choking. By moving the point of control to a sub-surface level, the constant higher bottom hole temperatures offset any drop in temperature due to gas expansion. The tubing string acts as a "Mile Long" heat exchanger utilizing the natural formation heat and eliminating the need for surface heaters.

Bottom Hole Choking as developed by Otis Pressure Control affords sub-surface control of many production problems.

Water encroachment is retarded and cutting is reduced. By taking advantage of bottom hole temperature and maintaining constant bottom hole pressure, water encroachment is retarded, thus reducing cutting and prolonging the flowing life of the well.

Maintains steady flow. Choking at a subsurface level usually makes possible the flowing of present day allowables through steady 24-hour low operation, in place of intermittent high rates of flow.

Reduces Gas/Oil Ratio. Where the choke can be set below the fluid level to prevent channeling, gas/oil ratios may be reduced.

KMA FIELD REDUCES GAS/OIL RATIOS...

Otis Type B Choke successfully used in wells with sufficiently high fluid level

The Otis Type B Choke has been extensively and successfully used in the KMA Field to reduce Gas/Oil ratios. It has been found that if ratios are not extremely high and there is a sufficiently high fluid level to permit the choke to be submerged, Gas/Oil ratios can be substantially reduced.

This is accomplished by using a Bottom Hole Choke with an orifice capacity smaller than the capacity of the formation to produce oil. The choke is set below the fluid level, near the bottom of the well and a fluid seal extending above the bottom of the tubing is set up. This condition usually results in a Gas/Oil ratio comparable to the solution ratio.

OTIS PRESSURE CONTROL, INC.
DALLAS, TEXAS

Highlights IN OILDOM

Crude Oil Discoveries Far Below Consumption

Petroleum Administrator for War Harold L. Ickes has announced that the amount of crude oil discovered in the United States during the year 1942 was only 801,000,000 bbl. by the most liberal estimate, or about 57 percent of the approximately 1,400,000,000 bbl. actually consumed during the year.

"This estimate," the administrator emphasized, "is a liberal and optimistic estimate of what might be expected on the most favorable probable basis.

"On the basis of the traditional engineering methods of estimating proved reserves of crude oil—under which all calculations are made on the conservative side—only 421,000,000 bbl. were discovered during the year."

"For the first time," he pointed out, "a federal government agency has made a survey of all the new oil fields actually discovered during the calendar year. As a result of this survey, it has been determined that, during 1942, a total of 261 new oil fields were discovered, and 74 new producing horizons were discovered in old fields."

Deputy Administrator Ralph K. Davies said of the report:

"It has been obvious for some time that in the past several years the United States has not been discovering new crude oil reserves in sufficient volume to equal the rate at which we have been taking oil out of the ground to meet the demand. We have been drawing on our accumulated capital to meet our current expenses.

"In ordinary times this would be somewhat serious, but not necessarily alarming, because the trend might soon be reversed. At a time when the nation is engaged in a life and death struggle, it becomes a matter for immediate concern. In order to determine the facts we have had this survey made by the Petroleum Administration for War staff. This is the first time that a Federal government agency has ever made a survey to determine the actual amount of new proved oil reserves discovered in any one year."

The results in the leading states were as follows:

	Proved Reserves Discovered 1942 Conservative basis, bbl.	*Possible maximum basis, bbl.*
Texas	169,065,000	282,655,000
California	25,625,000	143,460,000
Oklahoma	55,268,000	108,116,000
Louisiana	58,269,000	83,569,000
Kansas	49,084,000	80,389,000
Illinois	22,485,000	28,835,000
All other states	41,332,000	73,835,000
Total United States	421,128,000	800,859,000

In commenting on the relation of these figures to the East Coast petroleum situation, Davies pointed out that discoveries in the states of Indiana, Ohio, Kentucky, West Virginia, Pennsylvania, and New York accounted for only 1 percent of the total. The State of Michigan accounted for about 1½ percent of the 1942 discoveries. Thus, the only dependable sources of large quantities of oil continued to be in areas far distant from the East Coast, involving difficult transportation problems.

As to the effect the curtailment of drilling activity may have had on the discovery of new reserves, the deputy administrator said:

"We recognized early in 1942 that the wartime scarcity of steel would have a serious effect on the number of wells that could be drilled, therefore, we urged the petroleum industry to stress wildcatting wells drilled in an endeavor to locate new oil fields, and, within the limits of our powers, drafted all wartime regulations and controls in such a manner as either to encourage wildcatting directly, or at least to minimize the obstacles to such efforts."

Davies called attention to the figures, which showed that although the total number of wells drilled in 1942 decreased 40 percent from 1941, the number of wildcat wells declined only 7 percent. He stated that "this is positive evidence that our measures to encourage wildcatting brought results along the lines we sought."

The number of fields discovered in 1942 per wildcat well drilled when compared to the record in 1941 indicates that it was more difficult to find new oil fields. In 1941, two out of every 19 wildcats discovered new fields. In 1942 only two out of every 23 wildcats discovered new fields. The figures were 342 new fields discovered in 1941 from drilling 3264 wildcat wells versus 261 new fields discovered in 1942 from drilling 3045 wildcats.

Price Cost Report Fallacious, Says Brown

Russell B. Brown, general counsel of the Independent Petroleum Association of America, has termed as fallacious the recent report of the Tariff Commission on the cost of producing crude oil in the United States. He stated that the report was inconclusive and incomplete, adding that apparently it was made in coöperation with the Office of Price Administration, "whose repeatedly avowed purpose has been to keep prices stationary."

In support of his contentions, Brown pointed out that there are 19,000 oil producers and that the report contained "factual information" from only 2534. The 2534 producers, however, produce approximately 70 percent of the nation's oil, Brown said.

"This would indicate that the report covers companies of larger production," he said.

"This report covers periods for the calendar years 1939, 1940, and for the first, second, and third quarters of 1941. Therefore it is historical in nature. There is no effort to cover the cost of finding new reserves or to cover the replacement cost for oil sold."

Near Agreement on Hugoton Field Regulations

Kansas and Oklahoma are near agreement on regulations governing development of the Hugoton gas field, situated in both states, according to Harold Medill, retiring attorney for the Kansas Corporation Commission. A new basic order for Hugoton production has been approved by the Kansas commission and is being studied by Oklahoma officials.

The new procedure is designed to complete unitization of the field, giving landowners in developed areas a "just share of production royalties" and facilitating expansion in line with anticipated greater war demands.

At present the Kansas portion of the field is divided into zones for allocating production. Oklahoma has no gas proration regulations. This has resulted in a recent tendency toward greater development in Oklahoma than in Kansas, Medill said.

"When the two states get together on basic orders, as federal officials have encouraged us to, it will allow for equitable production from the common reservoir, with less waste," the Commission attorney asserted.

PENBERTHY PRODUCTS

Reflex

DROP FORGED STEEL LIQUID LEVEL GAGE

EMPTY SPACE SHOWS **WHITE** | LIQUID SHOWS **BLACK**

* * *

Transparent

DROP FORGED STEEL LIQUID LEVEL GAGE

USED TO OBSERVE COLOR AND DENSITY OF LIQUIDS UNDER HIGH PRESSURES, AND/OR TEMPERATURES

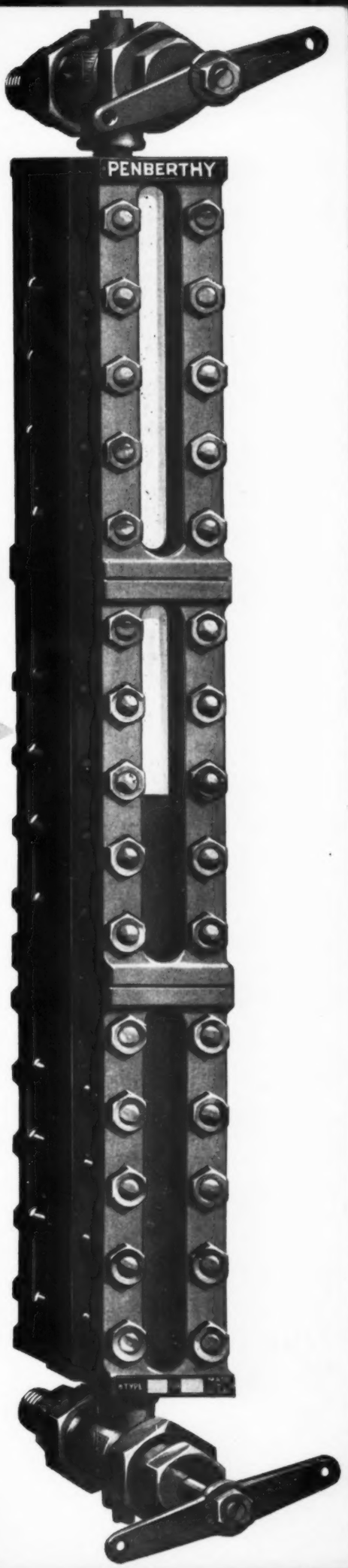
These gages are made of alloy temperature resisting steel and are of the highest quality throughout. Liquid chamber (both single and multiple section) is made from a solid block of steel to assure perfect alignment and rigidity. Frame has extra heavy beam at each end and glass chamber is accurately machined to contour of glass providing full metal backing for gaskets. Gage valves are drop forged steel with stainless trim.

These gages are available in any length and for various pressures and temperatures. All Penberthy gages conform with A. P. I.—A. S. M. E. requirements.

PENBERTHY INJECTOR CO.

DETROIT, MICHIGAN

Canadian Plant: WINDSOR, ONTARIO



MAJOR *Refining* ACTIVITIES

THE FIRST of the butadiene plants, which are to produce raw material from petroleum for the Government's synthetic rubber program, has begun operating at Baton Rouge, Louisiana, the Standard Oil Company (New Jersey) announces. The plant has a rated capacity of 6600 to 9000 tons of butadiene per year depending upon the quality of the petroleum fractions used as feed stock in the plant. This is enough butadiene to produce rubber for 1,300,000 to 2,000,000 tires. It is the largest plant yet put in operation for making synthetic rubber raw materials, it is stated.

The major construction work was completed by the contractor several weeks ago, and since then the Standard Oil Company of Louisiana has been putting the finishing touches on the plant, testing the various sections and bringing them successively into operation. The entire plant is now in full operation, and the finished butadiene is being delivered. Experience in operating this type of plant had already been obtained through entirely successful operation for a year of a smaller unit of the same design at the Baton Rouge refinery.

The plant just opened was under way prior to Pearl Harbor. It was planned and privately financed by Standard Oil of Louisiana, which intended to use the butadiene to increase its own production of special types of synthetic rubber that were in commercial demand even before the war. The company had originally scheduled completion of the plant for October 1, 1942, and the delay has been due to increasing shortages of critical construction materials since the outbreak of the war. Just before Pearl Harbor the Rubber Reserve Company contracted with Standard of Louisiana for the entire output of this plant, in order to speed up the Government's synthetic rubber program in which it was even then foreseen that the bottleneck would be butadiene supply. The output of this large plant will be of material assistance in meeting the present crisis in rubber supplies.

The butadiene, normally a gas, is shipped in pressure tank cars as a liquid to the rubber plants where it will be combined with styrene in the proportion of about three parts of butadiene with one part of styrene to form Buna-S. This is the synthetic rubber that the Rubber Reserve Company and the Baruch Committee found to be most suitable for tire production. Standard's technologists report that the product of the new plant is 99 percent pure, thus exceeding the strict government purity specification.

Three additional butadiene units at Baton Rouge, which are being wholly or partly financed by the Government, are well along toward completion, the company reported, and will be coming into production successively during the next next three months.

Standard Oil Company of Ohio is installing a $7,000,000 catalytic cracking unit at its Cleveland refinery, which is expected to be in operation within a year. Construction is being financed by Standard Oil, and a contract has been negotiated with Defense Supplies Corporation for purchase of the plant's production.

E. B. Badger and Sons Company, Boston, Massachusetts, is the general contractor for construction of the unit.

The General Tire and Rubber Company has entered into a contract with the government to operate a synthetic rubber plant in Texas, it is announced by William O'Neil, president.

The new plant is already under construction. The General Latex and Chemical Corporation of Cambridge, Massachusetts, will be associated with General Tire in the operation of the plant.

Butadiene for the synthetic plant will be provided by the Humble Oil and Refining Company, which also has under way the necessary buildings in the same town, O'Neil said.

The contract with the Rubber Reserve Company has been signed and the plant will be leased from the Defense Plant Corporation, both subsidiaries of the Reconstruction Finance Corporation. Harvey J. Elwell, president of General Latex and Chemical Corporation, will serve as general manager of the synthetic plant.

Both the synthetic plant and the butadiene plant are scheduled for completion in June of this year.

"We have been interested in the synthetic rubber program for many years," said O'Neil in announcing the signing of the contract. "We have believed that the polymerization of butadiene and styrene should be done at the point where the butadiene is made and the plan provides that this be done. In this way long transportation of butadiene gas is eliminated and the process from oil to rubber is almost continuous."

Although the operation of the plant will be in the hands of General Tire and Rubber Company, H. J. Elwell of General Latex will serve as general manager of the General Synthetic Rubber division of the General Tire and Rubber Company.

Phillips Petroleum Company has placed in operation the first commercial plant employing the hydrofluoric acid alkylation process for the manufacture of 100-octane gasoline components, Frank Phillips, chairman of the board, has announced.

In making the announcement Phillips said:

"The plant employs the basic principle of paraffin-olefin alkylation discovered some years ago by the Phillips research department and it was designed and built by the company's engineers to utilize an HF acid alkylation process developed within our organization.

"This catalytic agent—hydrofluoric acid—does not react permanently with the hydrocarbons being treated. Efficient operation is obtained with insignificant acid consumption. As a result, acid replacement costs are practically eliminated and there is no problem of acid-sludge disposal."

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels
Week Ended January 30, 1943
A.P.I. Figures
(Figures in thousands of bbl. 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Production	Total Gas and Fuel Oil Stocks
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	88.2	1,663	68.2	9,803	64,207
Appalachian	84.8	156	88.1	767	4,197
Ind., Ill., Ky.	85.0	740	91.2	4,024	25,419
Okla., Kans., Mo.	80.1	353	84.9	2,071	10,176
Rocky Mountain	48.0	99	67.3	579	2,790
California	89.9	687	84.1	4,435	86,861
TOTAL U. S.—B. OF M. BASIS JAN. 30, 1943	85.9	3,698	76.9	21,679	134,650
TOTAL U. S.—B. OF M. BASIS JAN. 23, 1943	85.9	3,615	75.2	21,613	196,352
U. S. B. OF M. BASIS JAN. 31, 1942		3,842		23,749	231,698

(a) Finished, 78,884,000 bbl.; Unfinished, 9,946,000 bbl.
*At the request of the Petroleum Administration for War.
[1]Production—total of gasoline at refineries including natural and blended; gas oil and distillate fuel, and residual fuel oil.
[2]Stocks—at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; gas oil and distillate fuel, and residual fuel oil.

A LESSON IN WATER COOLING

LESSON 1 OF A SERIES

PUMPING COSTS

TOTAL PUMPING HEAD is the amount of pressure required to circulate a liquid through a given system. The PUMPING HEAD required for a cooling tower is part of this total head and is that pressure necessary to lift water from the tower's base to its inlet and overcome friction within the distribution system.

The table indicates how very important PUMPING HEAD actually is when measured in terms of operating cost. These costs as tabulated will vary for any given installation in direct proportion to the actual GPM circulated and the power rate in effect.

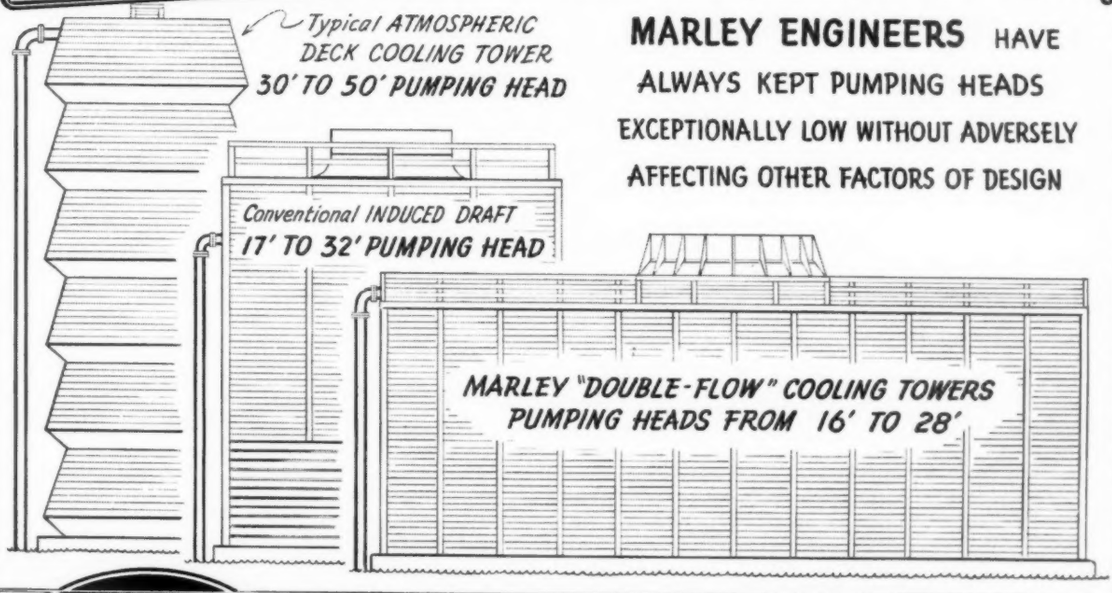
Unlike other tower operating costs resulting from the use of power, pumping head is generally figured on a full-time maximum GPM basis since this constitutes normal operating practice. Therefore any additional or unnecessary pumping head becomes a large factor in the complete comparative cost analysis so necessary for the intelligent selection of a cooling tower.

Relative pumping heads required by cooling towers of different types, designs and "makes" deserve the most careful study and comparison.

Cost Per 1000 GPM

at 1¢ per KWH and 70% Pump-and-Motor Efficiency

Pump Head	24 Hr. Day	30 Day Month	365 Day Year	Five Years	Ten Years
15′	$ .97	$29.10	$354.05	$1770.25	$3540.50
20′	1.29	38.70	470.85	2354.25	4708.50
25′	1.62	48.60	591.30	2956.50	5913.00
30′	1.94	58.20	708.10	3540.50	7081.00
35′	2.26	67.80	824.90	4124.50	8249.00
40′	2.58	77.40	941.70	4708.50	9417.00
45′	2.91	87.30	1062.15	5310.75	10621.50
50′	3.23	96.90	1178.95	5894.75	11789.50


Typical ATMOSPHERIC DECK COOLING TOWER
30′ TO 50′ PUMPING HEAD
Conventional INDUCED DRAFT
17′ TO 32′ PUMPING HEAD
MARLEY "DOUBLE-FLOW" COOLING TOWERS
PUMPING HEADS FROM 16′ TO 28′

MARLEY ENGINEERS HAVE ALWAYS KEPT PUMPING HEADS EXCEPTIONALLY LOW WITHOUT ADVERSELY AFFECTING OTHER FACTORS OF DESIGN

MARLEY **COOLING TOWERS**

THE MARLEY COMPANY, INC.

FAIRFAX AND MARLEY ROADS — KANSAS CITY, KANSAS

MAJOR *Oil Field* ACTIVITIES

ROESER and Pendleton-Continental Oil Company have opened a new Cook sand pool beneath five old wells drilled in former years. Cook Estate No. A-3 in Shackelford County, Texas, in the northwest of southwest quarter of section 139-ET RR, is a pumper good for 90 bbl. of oil per day from the Cook sand at 1605-11 ft. The well marks the seventh pool for the 18,000-acre Cook Ranch. The new field is one mile east of Dawson and Conway 17,000-acre ranch and three-fourths mile south of the 65,000-acre Nail Ranch.

A wildcat in Eddy County, New Mexico, found an estimated 2,000,000 cu. ft. of gas per day in lime at 2300 ft. Drilled to a total depth of 2310 ft., the well Broderick et al., State No. 1, section 8-17s-9e, topped lime at 2125 ft. Location of the wildcat is about two miles northwest of the Leonard area of Eddy County.

Stanolind Oil and Gas Company No. 1 Pattison, J. M. Bennett survey, north of the Katy gas field, drilled into the Katy gas sand at 6520 ft. and on an 11-minute drill-stem test produced gas with a working pressure of 1050 lb., indicating a major extension for the area. This test will be drilled deeper and at last report was below 6625 ft. in sandy shale.

A major northwest extension for the Ville Platte field of Evangeline Parish, Louisiana, was indicated by Jaubert Brothers No. 1, section 26-3s-2e, drilled by Continental Oil Company. Casing was being set at 10,290 ft. for completion of the well, which is located about one-half mile north of a producer.

The Amerada Petroleum Company et al. well Ingham No. 1, a wildcat in SW NW SE, section 28-20-4e, south of Glencoe and northwest of the Ingalls-Garr pool of northern Payne County, Oklahoma, showed oil in the Misener sand to forecast the discovery of another sand pool for the state. The well is located near an old and now abandoned region active from 1910 to 1930.

A two-mile extension has been discovered for the Ray pool of Phillips County, northwestern Kansas, by the Cities Service Oil Company well, Hansen No. 1-D, in SWC SE, of 14-5s-20w. A potential of 1626 bbl. per day was given by the Kansas Corporation Commission. The Lansing-Kansas City lime was found from 3292 ft. to 3337 ft. and from 3364 ft. to 3370 ft. At 3595 ft. the Arbuckle lime was found with granite from 3789 ft. to 3799 ft. At 3700 ft. 4½-in. casing was set and the lower level of the Lansing-Kansas City lime perforated from 3360 ft. to 3371 ft. The well produced 10 bbl. per hour for nine hours.

Discovery of a new producing area in Illinois has been made by The Pure Oil Company. Earnst No. 1, NW 31-3n-9e, Richland County, recovered 600 ft. of oil and 60 ft. of oil-cut mud without any water on a drill-stem test in the McClosky lime between 2984 ft. and 3005 ft. The tool was open one hour. At last report the operator was waiting for cement to set with casing 2,982 ft.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.23-1.29	Rodessa	$ .88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.93-1.36
Coalinga	.73-1.13	North Louisiana	.98-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	Illinois	1.22-1.37
Wyoming	.45-1.15	Kentucky	1.32-1.43
Colorado	1.05-1.07		
New Mexico	.70-1.15	Indiana	.85-1.25
Texas		Ohio	
North Central	.97-1.21	Lima	1.50-1.60
Panhandle	.70-1.12		
West Texas	.80-1.27	Michigan	1.24-1.44
Gulf Coast	.93-1.48		
Darst Creek	1.14	Pennsylvania	
East Texas	.80-1.27	Bradford	3.00
Talco	.79	Southwest	2.65
Kansas	.93-1.25	Eureka	2.59
Oklahoma	.75-1.25	Buckeye	2.55
Arkansas	.94-1.36	Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION
Data Supplied by A.P.I.
(Figures in bbl. of 42 gal. each)

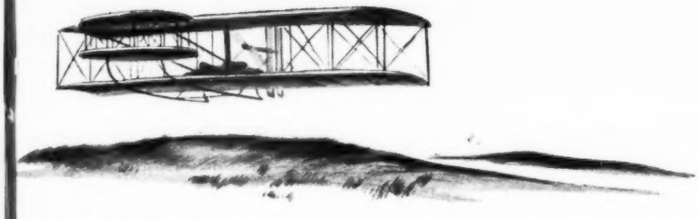
	[1]P.A.W. Recommendations January	Week Ended Jan. 30, 1943	Week Ended Jan. 2, 1943	Week Ended Jan. 31, 1942
Oklahoma	400,600	[2]374,750	354,000	408,850
Kansas	310,000	[2]291,800	288,350	251,200
Nebraska	3,400	[2] 2,350	2,850	5,250
Panhandle Texas		88,400	90,300	75,500
North Texas		136,700	138,600	144,350
West Texas		201,100	206,750	242,450
East Central Texas		101,600	101,300	80,000
East Texas		327,600	350,600	291,000
Southwest Texas		166,700	177,500	186,550
Coastal Texas		308,800	311,100	250,150
TOTAL TEXAS	1,426,800	1,330,900	1,376,350	1,270,000
North Louisiana		91,850	93,150	81,000
Coastal Louisiana		247,700	223,000	285,800
TOTAL LA.	347,500	339,550	316,150	366,800
Arkansas	78,300	74,900	75,000	74,500
Mississippi	50,000	[2] 55,300	56,850	79,750
Illinois	272,600	229,550	254,600	370,000
Indiana	17,200	[2] 16,600	15,700	20,750
Eastern (Not incl. Ill. & Ind.)	107,600	94,500	93,300	100,800
Michigan	63,700	60,800	59,300	51,300
Wyoming	94,500	89,950	85,750	89,050
Montana	24,700	22,300	22,550	20,800
Colorado	7,000	6,350	6,500	6,650
New Mexico	105,300	98,300	93,350	119,350
TOTAL EAST OF CALIF.	3,309,200	3,060,900	3,100,600	3,325,050
California	815,000	765,500	770,000	636,300
TOTAL U. S.	4,124,200	3,826,400	3,870,600	3,871,350

[1]P.A.W. recommendations and state allowables represent the production of all petroleum liquids, including crude oil, condensate and natural gas derivatives recovered from oil, condensate and gas fields. Past records of production indicate, however, that certain wells may be incapable of producing the allowables granted, or may be limited by pipeline proration. Actual state production would, under such conditions, prove to be less than the allowables. The U. S. Bureau of Mines reported the daily average production of natural gasoline and allied products in October, 1942, as follows: Oklahoma, 30,000; Kansas, 5,200; Texas, 103,700; Louisiana, 20,500; Arkansas, 3,000; Illinois, 10,300; Eastern, (not including Illinois and Indiana) 10,400; Michigan, 100; Wyoming, 2,600; Montana, 300; New Mexico, 5,700; California, 42,200.

[2]Oklahoma, Kansas, Nebraska, Mississippi, Indiana figures are for week ended 7 a. m., January 27.

ONLY EXPERIENCE

fosters special skill



Specialized skill and knowledge obtained through years of pioneering experience are the unseen assets determining the success of any technical service. Oil Well Chemical Service is no exception to this rule.

Dowell is a pioneer in oil and gas well chemistry. It has had more than a decade of oil field experience. Back of its carefully engineered equipment stands a wealth of skill and knowledge gained by treating many thousands of wells.

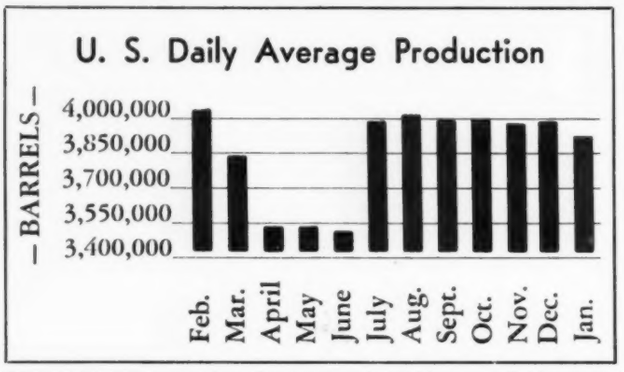
Contributing to further advancements in this field is Dowell's parent organization, The Dow Chemical Company. Dow's nationwide facilities and expert scientific knowledge assist Dowell in solving oil production problems.

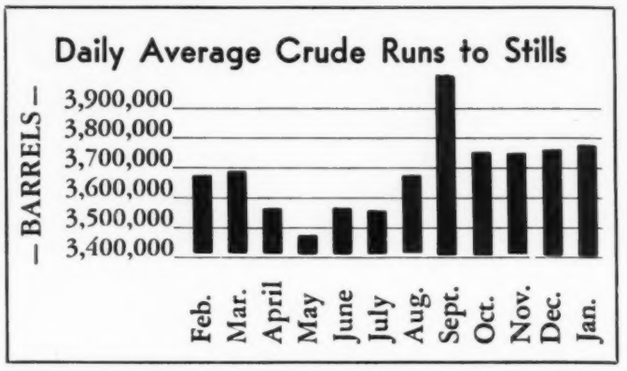
Dowell's pioneering experience has secured an international reputation for dependability and success.

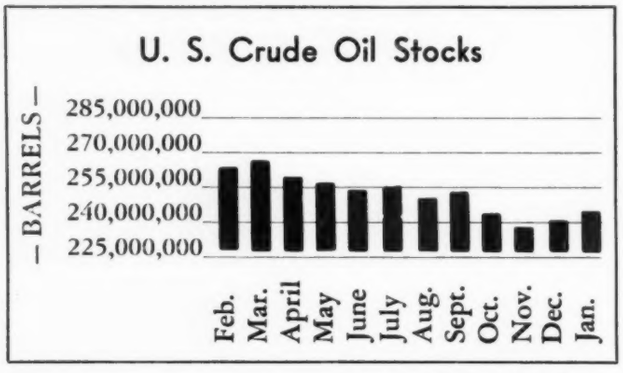
DOWELL INCORPORATED
Executive Office: Midland, Michigan
General Office: KENNEDY BLDG., TULSA, OKLAHOMA
Subsidiary of The Dow Chemical Company

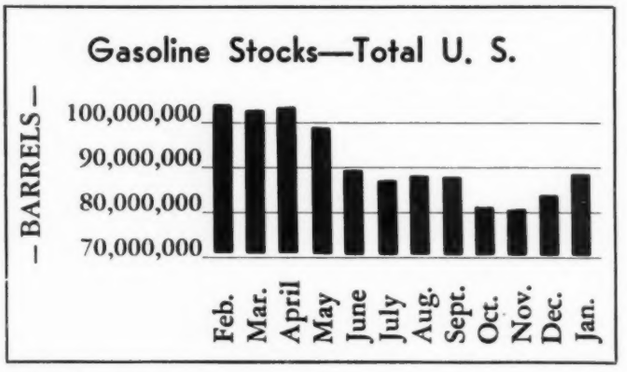
Look to
DOWELL
FOR OIL AND GAS WELL CHEMICAL SERVICE

PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for January, 1943

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	30	21	3	....	3500-3700	2	40	Rotary
Gaines County	2	1	5	....	4400-5584	2	22-35	Rotary
Hockley County	7	4	3	....	4800-6850	2	20-30	Rotary
Ector County	5	3	5	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	28	20	4	....	1700-3900	2	40	Rot.-Cab
Nueces County	6	5	6	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	7	4	4	....	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	12	10	5	....	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	6	3	7	5	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	11	9	6	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	5	2	5	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	8	6	2	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	168	147	68	140	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	16	12	5	4	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	3	2	4	1	1840-11,450	3 or 4	14-30	Rotary
Wilmington County	2	1	3	1	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for January, 1943

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1942 (In Barrels)
	January	December	January	December	January	December	January	December	January	December	
Arkansas	8	16	6	13	14	11	3	4	15	11	26,560,000
California	81	47	77	41	21	20	33	29	38	27	248,250,000
Illinois	168	175	147	155	46	52	68	58	140	138	105,768,000
Indiana	20	28	18	25	11	18	4	3	6	12	6,680,000
Kansas	124	127	118	120	53	62	13	16	17	25	96 920,000
Kentucky	11	8	7	5	7	3	....	....	....	....	4,503.000
Louisiana	171	186	153	177	39	50	11	15	14	16	125,450,000
Michigan	27	28	19	22	5	7	9	12	3	5	21,568,000
Mississippi	3	3	1	1	....	....	....	....	....	....	27,605,000
Montana	10	11	8	7	....	....	....	....	....	....	8,998,000
Nebraska	2	3	1	1	2	4	....	....	....	....	1,367,000
New Mexico	29	49	26	44	20	31	....	....	....	....	31,875,000
New York	84*	73*	68*	64*	47	51	....	....	....	....	5,132,000
Ohio	61	46	45	39	36	30	....	....	....	....	3,480,000
Oklahoma	125	143	120	128	14	28	4	3	61	77	138,750,000
Pennsylvania	131*	109*	113*	101*	107	119	....	....	....	....	17,256,000
Texas	421	493	388	418	314	331	291	325	310	340	476,560,000
West Virginia	37	31	31	26	17	10	2	4	7	11	3,780,000
Wyoming	4	2	2	1	4	3	1	2	1	2	32,778,000
Total	1517	1578	1343	1388	757	830	439	471	612	664	1,383,280.000

*Includes water-intake and pressure wells.

Baash-Ross News

BAASH-ROSS TOOL COMPANY · LOS ANGELES · HOUSTON · NEW YORK

PETROLEUM ENGINEER EDITION

Priority Troubles?

WHY NOT MAKE YOUR SPARE DRILL COLLAR INTO A MODERN HEX KELLY!

Here Are Helpful Suggestions For Doing The Job

Most oil men today are generally agreed on one point—that for top dollar performance... for longest service life... and for lowest maintenance... the Hexagonal Kelly stands definitely out in front as the *one* type of kelly that meets *all* modern drilling requirements. For example...

- A Hex Kelly stays straight longer because it is 23.2% more resistant to common bending stresses than the same sized square kelly...
- A Hex Kelly is *better balanced* for today's high speeds because it is *machined* to shape, permitting closer tolerance controls...
- A Hex Kelly has 48% more circulation area than a comparable sized square, providing ample fluid passage for modern high-volume pumps....
- A Hex Kelly has 28.6% greater *torsional* strength... and 1.8% more *tensile* strength than comparable square kellys—two *vital* advantages...
- And finally, the Hex will handle ALL types of drilling—*both* regular and pressure work—*without change!*

If you already have Hex Kellys working on your rigs, you know by actual performance why they are today's outstanding kelly value. But if lack of necessary wartime priorities makes actual purchase of *new* kellys impossible, Baash-Ross engineers have worked out a simple solution that may enable you to obtain many advantages of Hex Kelly construction without the need for new equipment purchases whatever. Here's how:

You probably have a spare drill collar on your racks that can be economically machined into a Hex Kelly. But in selecting a drill collar for this change-over, keep these points in mind...

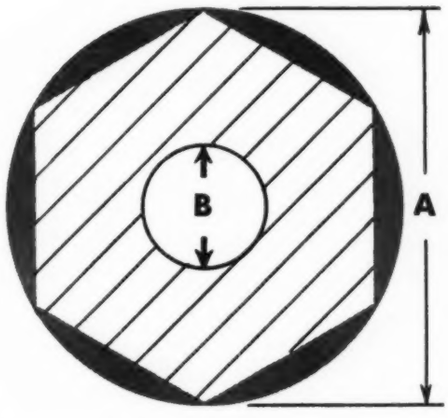
1. Allow 16" for the top upset and 20" for the bottom upset.
2. The remaining distance (the driving area) should be 35 to 37 feet long to handle Range II pipe lengths.

Thus, a 39 foot drill collar, after allowing 3 feet for top and bottom upsets, will give you a finished Hex Kelly with a driving area about 36 feet long—ample for Range II pipe.

The size of the collar and the size of the kelly it will make are shown in the table below. A 7" diameter round collar of proper length, for example, will machine into a kelly capable of handling 4½" or 5 5/16" drill pipe. It should have a bore of not more than 3½" to 4" to assure ample strength factors after outside stock has been cut away to make the hex "flats."

And here's a point to remember: If your spare drill collar is a Baash-Ross "Trubore," it will probably meet the specifications suggested in the table as to diameter and bore for the given pipe size. Any collar you use, of course, must be of the non-tapering type to provide for full length Hex Kelly construction.

For further information on this conservation suggestion, write to the Baash-Ross Tool Co., Los Angeles, California.



The Table below shows the size Hex Kellys you can make from various diameter drill collars. Allow 16" for top upset and 20" for bottom upset. There should be at least 35 feet of hexagonal driving area to handle Range II pipe lengths.

If the diameter "A" of your drill collar is...	7¾" to 8"	7"	5¾"	5"	4¼"
And the bore "B" is...	3½"-4¼"	3½"-4"	2⅞"-3½"	2"-2½"	1½"-2"
You can make a Hex Kelly to handle pipe sizes...	5 5/16"-6⅝"	4½"-5 5/16"	3½"-4½"	2½"-3½"	2⅜", 2½", 3½"

Drive your new Hex Kelly with a Baash-Ross Kelly Bushing!

The smooth, even, frictionless feed of the Baash-Ross Roller Kelly Bushing in all types of drilling—under all conditions—makes it the ideal tool to use with your Hex Kelly. The better performance of your Hex, plus the full control over bit and drill string you get with this roller bushing is an unbeatable combination for every operation.

Baash-Ross Kelly Bushings—for either hexagonal or square kellys—are built through and through to take the punishment of modern high speed drilling operations. In fact, this equipment will withstand rotational speeds of a thousand r.p.m. or more—far greater than present-day speeds, proof of the stamina engineered into these units. Simple, low-cost maintenance... easy replacement of wearing parts... superior kelly control on every job—these are the performance points you want—and get—in Baash-Ross Roller Kelly Bushings. Ask your nearest Baash-Ross representative for details—or write direct!

MAJOR *Pipe Line* ACTIVITIES

PETROLEUM Administrator for War Harold L. Ickes has announced that work is scheduled to begin in March on the construction of a second big oil pipe line to boost movement to the East Coast, an 836-mile, 20-in. line designed to deliver 235,000 bbl. of petroleum products daily from Texas to tank car loading points in Illinois and Indiana.

The Administrator's announcement followed War Production Board approval of the project, subject to final review by the Requirements Committee. He had recommended it to WPB as "the surest, most economical in terms of material and manpower and the most dependable method for meeting military and essential civilian requirements for petroleum products during the winter of 1943-44."

If work begins and proceeds on schedule, and if there are no interruptions to the flow of construction materials, the line can be completed on or about September 1.

Upon completion of the details, the Defense Plant Corporation, a subsidiary of the Reconstruction Finance Corporation, will be requested to finance the project, which will be built for the Government by War Emergency Pipelines, Inc. The estimated cost is $44,000,000.

War Emergency Pipelines, Inc., is the company organized by the petroleum industry to construct the 24-in. pipe line now being built from Longview, Texas, to the New York-Philadelphia refining area.

Administrator Ickes said:

"The new 20-in. pipe line is a 'must' in the comprehensive oil-for-war program of the Petroleum Administration. Its completion by September 1, 1943, will help assure the meeting of basic military and essential civilian requirements for petroleum products during the latter part of this year and the early months of 1944."

The line will deliver light petroleum products from refineries in the Beaumont-Houston area of Texas to tank car loading terminals at Norris City, Illinois, and Seymour, Indiana. Its operation will result in a net additional delivery by tank car of 110,000 bbl. of petroleum products daily to Eastern Seaboard consumption and export centers. This additional delivery represents the difference in effective delivery rate that can be obtained by shuttling tank cars on the shorter route between Midwest terminals and the East Coast as compared with the rate possible by using the same cars over the longer-haul run between Texas loading points and the East Coast.

Citing the fact that more than half of the new pipe line will be laid along the same right-of-way already traversed by the 24-in. War Emergency Pipeline and thus save thousands of dollars in construction costs as well as many weeks of preliminary labor, Deputy Petroleum Administrator Ralph K. Davies said:

"The line will link the principal Texas refining area with the most effective Midwest junctions for tank-car trans-shipments to the East. These tank car loading terminals, now under construction at Norris City and to be constructed soon at Seymour will be used for lifting War Emergency Pipeline deliveries until the extension of that line is completed through to the East Coast next June. They will then be available for similar service in connection with the new products pipe line pending later determination of the feasibility of extending this line all the way to eastern terminals.

"We have every reason to believe that the veteran pipeliners who pushed the Texas-Illinois section of the 24-in. pipe line to completion in record time will be able to duplicate and perhaps better their excellent construction record on this new war job. Many of them are now working on the eastern extension of the 24-in. line, but they will reinforce the crews that will start construction on the second 'big inch' as fast as they complete their assigned sections of the War Emergency Pipeline."

PAW pipe-line officials said that orders for materials for the new Texas-Illinois-Indiana line are in preparation and that contracts will be let as quickly as possible.

Construction operations will be streamlined in accordance with practices established in the laying of the War Emergency Pipeline between Texas and Illinois and now being followed in the work on the eastern extension of that pipe line. These operations involve simultaneous construction of several sections, with all work scheduled to assure simultaneous tie-in of all the working "spreads" on the scheduled completion date.

Plans call for the use of 20-in. seamless steel pipe on the main 836-mile section of the pipe line but welded pipe will be installed if deliveries of seamless tube cannot be obtained in adequate quantity to maintain uninterrupted construction.

Eighty-three miles of 16-in. pipe will be laid as a feeder from Houston to Beaumont and 32 miles of 10¾-in. pipe will be laid as another feeder line from Port Arthur to Beaumont. Thirty-four miles of second-hand 8⅝-in. pipe will be laid as refinery tie-ins near Baytown and Texas City.

Sixteen pumping stations equipped with a total of 44 motors and pumps capable of producing 55,000 hp. will be installed to maintain the 235,000 barrel-a-day flow between Houston and Beaumont, Texas, and Seymour, Indiana.

A decision with respect to the feasibility of extending the new 20-in. line to the East Coast is expected to be made on the basis of a supplementary report by the Petroleum Administration for War on or about May 1, 1943. The necessity of the line as presently recommended has been thoroughly established, but it was considered advisable to postpone recommendation of the full Texas-East Coast span for petroleum products until additional data on the operations of all petroleum carriers through the winter could be obtained.

◆

Production of "big inch" pipe for the Eastern portion of the Texas-East Coast oil pipe line at the National Tube Company's Lorain, Ohio, works is at the record pace of 5.8 miles a day, this U. S. Steel Subsidiary has reported to the Petroleum Administration for War.

Having completed delivery of pipe for the western portion of the line being built by War Emergency Pipelines, Inc., in exactly four months from the time production began, National Tube immediately began turning out the main-line material to complete the eastern segment of the project, which will bring Texas crude and fuel oil to the East Coast shortage area.

The company reported that it had maintained a pace of 5½ miles a day in producing pipe for the western portion of the line from Longview, Texas, to Norris City, Illinois.

On the eastern section, 230 miles or 1894 carloads of pipe, had been produced and delivered by January 21.

Since July 10, 1942, when initial work on the line was begun, more than 6400 carloads of pipe for this vital phase of the war effort have been delivered.

THE Petroleum Engineer

FEBRUARY, 1943

Drawworks of Improved Design For Slim-Hole Rig

PETROLEUM ENGINEER Exclusive Feature

☆ Friction clutches for hoist, rotary, and cathead mounted on line shaft—Improved positive-type clutch reduces shock

by C. C. Pryor
Associate Editor

SLIM-HOLE drilling is not new to the drilling division of the petroleum industry; however, the development of rigs for slim-hole drilling have been almost continuous. Such rigs have proved their efficiency and are popular in the industry for drilling wells to depths of 7500 to 8000 ft. The majority of the slim-hole rigs have internal combustion engines that utilize gas, gasoline, or butane as fuel and can convert from one fuel to another with little effort. The flexibility of the steam-powered rig and the performance-efficiency of the heavy-duty rig have provided a dual criterion in the design and construction of slim-hole rigs. New ideas are continually being incorporated into engine compounding, transmissions, and drawworks, with flexibility, compactness, lightweight, low first costs, and low maintenance costs as the principal aim.

A slim-hole rig now in operation on a wildcat near Groesbeck, Texas, uses natural gas for fuel, and is one of three rigs of similar design that have drilled more than 346,000 ft. of hole and made a remarkable record for this type of rig. Using 3½-in. O.D. internal flush-external upset, 11.20 lb. per ft. drill pipe, and three to six 5½-in. O.D. 30-ft. drill collars, the operator has experienced only minor difficulties during the entire footage drilled. In the first well drilled by one rig there were two failures in a new string of drill pipe. Both occurred within 48 hours of each other. Since that time only the normal amount of drill collar breakage and tool joint washouts has occurred.

General view of rig across mud pits showing layout of equipment and substructure

Drawworks and Power

A predominant feature of the entire rig is the drawworks. The motors, transmission, and drawworks are mounted on 64-lb. H-beam master skids and are moved from location to location as a unit. The lightweight, compactness, and simple design of the unit greatly aid in moving and rigging-up. Power for the drawworks is supplied by two 6-cylinder engines of 185-hp. at 1300-r.p.m., which use gas, gasoline, or butane. Each engine is equipped with one friction clutch of the non-positive-type and compounded by chain drive of 1-in. pitch and triple width. Either engine may be used separately by disengaging the friction clutch. The hub from the clutch through the compounding sprocket then serves as a countershaft.

Transmission

From the motors to the input shaft of the transmission a chain of 1-in. pitch and quintuplet width is used. The transmission of the rig is unusual in design. It supplies three speeds forward

Front view of drawworks on rig floor from driller's stand. Controls are placed for easy operation

and one reverse. All-steel construction is employed throughout, including the case, without the use of castiron. Outboard bearings were eliminated by properly spacing bearings of the roller antifriction type in the transmission. The transmission case is flat-bottomed, as the input and output shafts depart from the usual method of being mounted one above the other and are both on the same level. Four bolts on each end of the case secure it to the same base as the engines and drawworks. One of the features of compactness and new design is the lubrication system of the transmission. The first train of gears in the box are 3¼ in. in width and the remainder are 4 in. By constructing a lightweight sheet-metal housing around the reverse idler gear and its mating gear on the countershaft, a gear oil pump is provided for force-feed lubrication of all bearings and gears. To open the transmission box for inspection or repairs, it is only necessary to remove the bolts holding the top section in place and all gears, shafts, and bearings are readily accessible.

Friction Clutches and Brakes

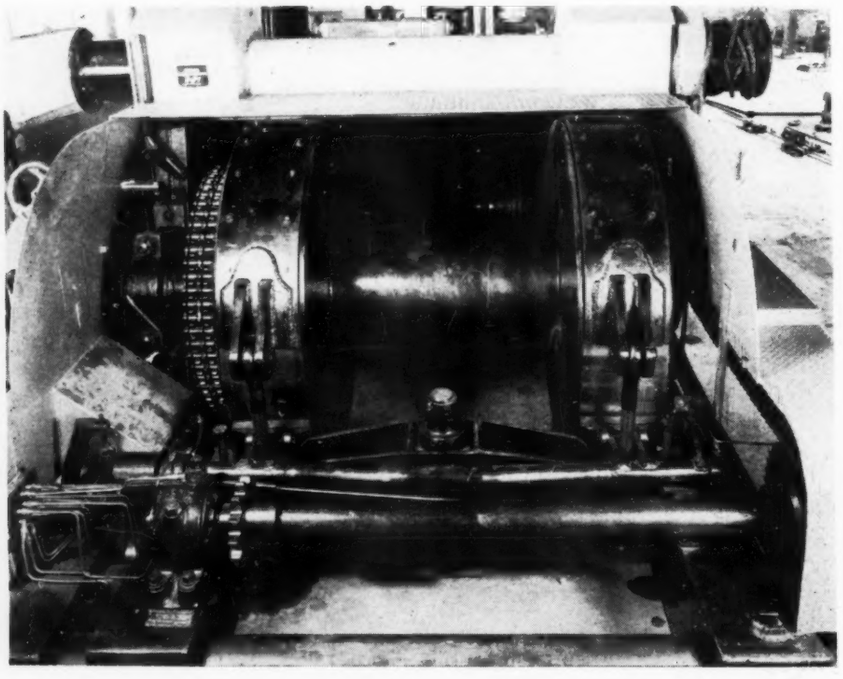
Another of the unusual features of the drawworks is the method of using friction clutches for the hoist, rotary table, and cathead. One long shaft through the drawworks serves as the main or line shaft. Separate friction clutches are mounted on this shaft for the hoist, rotary table, and cathead. In addition to the separate friction clutches mounted on the one shaft, the hoist and rotary table are each equipped with a brake synchronized with the friction clutch control. When the friction clutches are engaged the brakes are in a released position, but when the clutches are disengaged, the brakes are automatically set. All controls are mounted at the driller's stand and are quickly and easily handled.

All chains except two are totally enclosed and in a constant oilbath. According to the operator, the life of chains on the rig is unusually long, due to the lubrication system, and the clutches, chain speeds, and chain pitches, which relieve unnecessary strain on both chain and sprockets. Alemite lubrication from centrally controlled panels assure ease and certainty of lubrication, eliminating reaching through chains, etc. The drum drive and cathead chains remain idle when rotating, the rotary drive and cathead chains remain idle when hoisting, and the drum and rotary drive chains remain idle when using the cathead.

The Hoist Drive

The first chain from the transmission output shaft is 1¼-in. pitch and triple width and transmits power to the lineshaft from which power is taken by the three clutches for the hoist, rotary, and cathead. From the lineshaft hoisting friction clutch to the hoist countershaft a 1¼-in. pitch chain of quadruple width connects with the drum counter shaft. High- and low-speed drum chains are 1¾-in. pitch double width (heaviest chain on rig). Six speeds are provided by the high and low gears and transmission for the drum, which has a spool diameter of 18 in. and is 32 in. long. The drum is of the smooth type and will accommodate 1- and 1⅛-in. cable. It is of free-wheeling design and none of the drum chains are in motion while drill pipe is being run into the hole.

The brakes for the drum are 46-in. in diameter and 10 in. wide. Instead of equalizing the brake bands on the "live ends" the brakes are equalized on the "dead end" with a one-point adjustment for both brakes. This adjustment can be made while the driller is run-



Drawworks with housing removed. Pin to adjust brakes is between the drum flanges in foreground. Lubrication panel is at extreme left. The small sprocket for drilling the rathole is on the left end of the rotary drive countershaft

Mud pump suction pit and mud pump and engine at extreme left. Mud discharge line is shown in lower left

ning pipe in the hole and can be accomplished very quickly for both bands. The brake rims are cooled by both air and water—air current being circulated around the brake rims by specially designed vanes and baffles.

In addition to the friction clutch for the hoist, positive-type clutches are employed on the drumshaft proper. There are 36 teeth in the low-speed and 42 in the high-speed clutches on the drumshaft. The high speed on the drum is about 3 times as fast as the low speed, giving plenty of speed to the traveling block going up empty and power when picking pipe out of the slips in low. Use of these positive-type clutches permits the friction clutch employed to be comparatively small and of ordinary construction as practically all shock is eliminated by the special positive clutches. The smaller clutch is thus mounted in the high-speed section ahead of the positive-type clutches. Both high and low drum drive chains are disengaged, minimizing wear and strain when drill pipe is being lowered in the hole due to the line shaft design.

DRUM SPEEDS

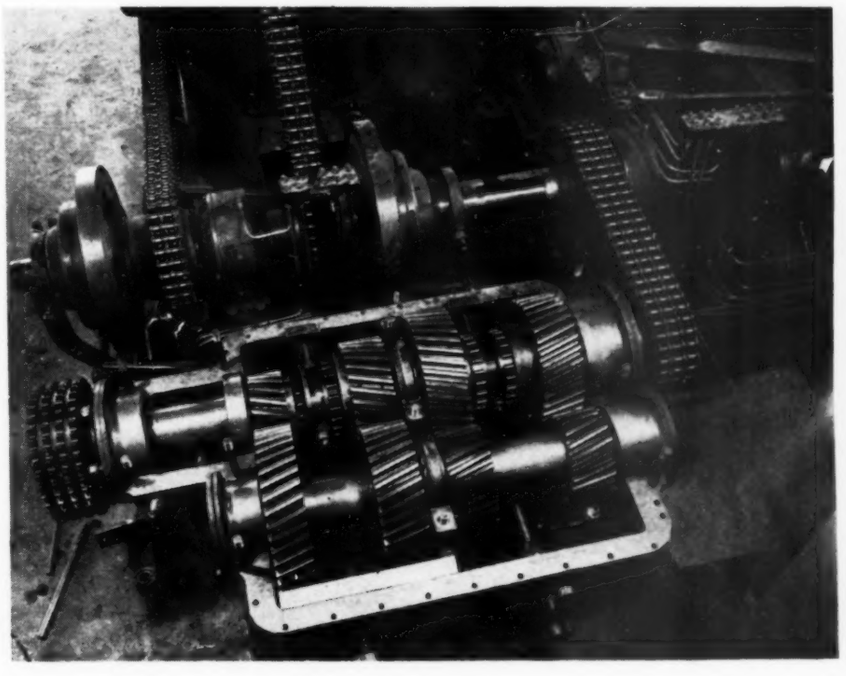
Low side	
High gear in transmission	151 r.p.m.
Second gear in transmission	82 r.p.m.
Low gear in transmission	42 r.p.m.
High side	
High gear in transmission	451 r.p.m.
Second gear in transmission	245 r.p.m.
Low gear in transmission	126 r.p.m.

The Rotary Drive

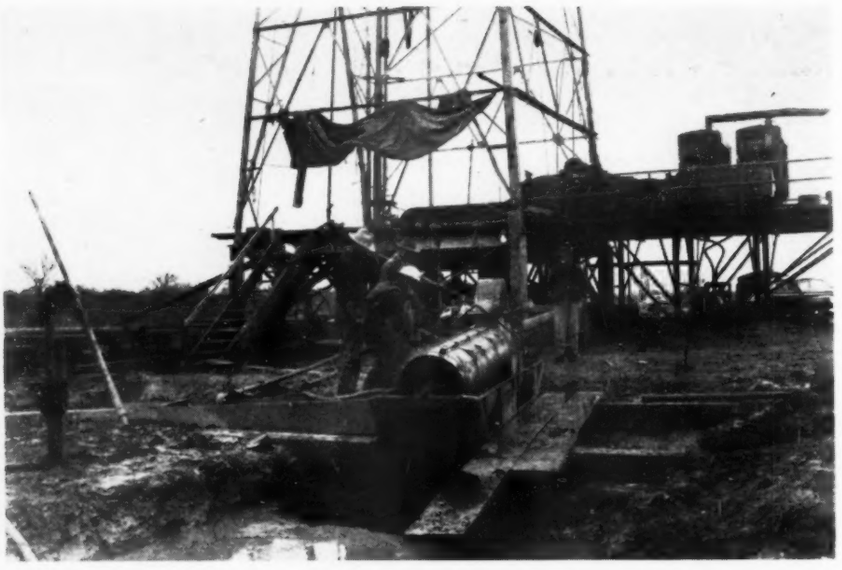
A 1¼-in. pitch double width chain transmits power from the rotary friction clutch on the lineshaft to the rotary countershaft. From the rotary countershaft a 2-in. pitch single width chain connects to the 17½-in. fully-enclosed constant oilbath rotary table. The rotary countershaft about 5 ft. in length has bearings inside the sprocket for the rotary table chain. With the bearings situated on the inside of the sprocket it was possible to change the speed of the rotary table even beyond the three speeds of the transmission and the change of speed available by changing motor speed. To accomplish this change, the drive sprocket to the rotary table is equipped with a flanged hub and eight ¾-in. cap screws and several sprockets designed to give a change in speed. A member of the crew can quickly change the sprocket by removing the eight cap screws releasing the sprocket and bolt the sprocket in place that will provide the desired speed. This arrangement permits changing of worn sprockets and longer life of each sprocket is assured by reversing it to allow the chain to wear on the opposite side of the sprocket teeth.

The rotary table countershaft containing the interchangeable sprocket for the rotary is equipped with a small sprocket on the opposite end, which is keyed to the shaft and is left there as a part of the equipment. To drill the rathole the rotary is skidded into position so that the small extra sprocket is lined-up with the rotary table sprocket, the chain replaced and the rathole quickly drilled. Then the table is skidded back into position over the hole and the chain replaced on the regular drive sprocket. Thus the rotary table countershaft serves a triple purpose. It eliminates using a long chain, subject to slapping and excessive wear, to the table from the driveshaft; permits a greater variation in rotary speeds by the simple procedure of changing the sprocket on the countershaft, and provides a simplified arrangement for drilling the rathole.

Heavy tread-plated streamlined hous-



Partially assembled transmission in the shop. The input sprocket from the engines is at the left, output sprocket at right. Line shaft with friction clutches for hoist, rotary, and cathead is connected to output sprocket with triple-width chain



Crew members preparing to remove sample of cuttings from sample box of Pelton-wheel rotary-type shale shaker

ing protects the drilling crew from injury and keeps out dust and rain. It can quickly be removed for inspection.

Derrick and Substructures

A 129-ft. derrick of angle steel construction of 507,000-lb. capacity with a 24-ft. base, a 5-ft. 6-in. water table, and a 7-ft. substructure completes the rig proper. The height of the rig permits the pipe to be racked when coming out of the hole in stands of 90 ft. Bracing and substructure beneath the derrick is of the usual I-beam type, however, beneath the engine and drawworks structure welded pipe is employed as a substitute for I-beams where practicable. Flooring around the engines and drawworks is laid on beams of 2-in. pipe. Sockets are welded to the main substructure and the 2-in. pipe held in place by pins passing through the socket and pipe. One end of a section of 2-in. pipe is welded to the pipe serving as floor beam and the other end fits into another socket welded to the lower part of the main substructure and thus serves as a brace. This type of flooring is quickly assembled or torn down by the rigging crew as three men can assemble it in a little more than 2 hours.

Mud Pumps

Only one main mud pump is employed on the rig of 7¼-in. by 14-in. with 10-in. suction, and 300-hp. input capacity at 60 r.p.m. Liners are used in the pump depending on the depth and size of the hole. The maximum pressure at which the pump is operated is 1400 lb. per sq. in.; 800 to 1100 lb. per sq. in. is the usual operating pressure. Liners down to a 5½-in. size are used. Power for the pump is supplied by a V-12 cylinder, gas, gasoline or butane engine delivering 325-337 hp. at 900 r.p.m. A friction-type clutch delivers power to a V-belt sheave, which in turn transmits power to the pump sheave with 14 V-belts. Both the pump and motor are skid-mounted with separate skids provided for the engine to facilitate moving from one location to another. In operation, the engine is set across the pump or main skid, which is slotted to permit the engine to be moved back by a turnbuckle arrangement to adjust the tension of the V-belts. An auxiliary mixing pump 6¾-in. by 12-in. is driven by a 125-hp. gas, gasoline, or butane engine. All engines on the rig are enclosed by sheet-metal housing.

Mud Returns Sampler

The shale shaker on the rig is of the Pelton-wheel type and has a sample catcher attached. Mud from the discharge line of the well turns the Pelton wheel, which by means of bevel gears and V-belts causes rotation of the separating drum. The sample catcher, which is of great benefit to the operator, operates on the same principle as the shaker and supplies a clean sample at all times for inspection. The discharge line from the blowout preventer has a 6-ft. section of 8-in. suction hose about 5 ft. from the preventer. This hose is connected to the line by clamps. About 10 ft. from the end of the hose section an ell is placed in the line to direct the pipe toward the mud pits. This method of arranging the discharge mud line permits the operator to move the end of the line to either of two pits and the shaker without further pipe connections, thus greatly facilitating rigging-up.

In the wildcat well being drilled by the rig at present, 10¾-in. surface casing has been set by the operator. The blowout preventer is of the dual type, the lower section containing the drill pipe rams and the top section the blank rams. This permits close control of the well at all times.

Acknowledgment

The author is indebted to Roy Guffey, The Roy Guffey Drilling Company, who designed and whose company is now drilling with this rig, for much of the material and information herein presented.

☆ ☆ ☆

Substructure under drawworks and engines is of simplified design reducing rigging-up and moving time

Standard Drilling Equipment Adapted to Marine Operation

PETROLEUM ENGINEER Exclusive Feature

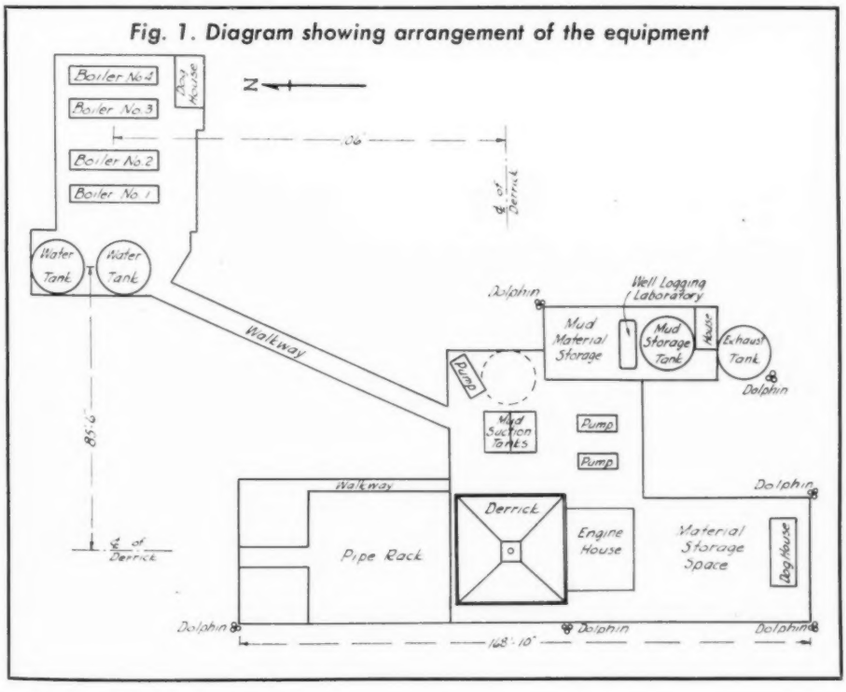
☆ Shortage of materials prevents full use of customary marine drilling equipment for deep California test

by Wallace A. Sawdon
Pacific Coast and Foreign Editor

EAST of the southern nose of Kettleman North Dome lies the Tulare Lake Bed, which, during dry cycles, is covered with little or no water. During the last five or six years this depression has been full of water and at the present time forms a lake of considerable extent. Geological study and geophysical prospecting both have been conducted extensively on the lake bed and surrounding territory and a number of wells have been drilled in the area. Deeper prospects are now being given greater consideration. Shell Oil Company, Inc., decided to drill a deep test in this area, but the location believed to be most favorable, and thus the one selected, is now covered with the waters of Tulare Lake. The well is Shell Oil Company's T.S.G. No. 21-28.

Development of the technique of marine drilling under a variety of conditions is such that the drilling of this well should present no difficult problem. The shortage of materials that now confronts the operator, however, does present handicaps and even prohibits the construction of any new barges necessary for the conduct of operations. The well location is two miles from shore at the nearest point but, because of deep water, is three miles from the point on shore most adaptable for a dock location. The distance from shore eliminated consideration of directional drilling and made a vertical-hole location on the Lake most advantageous. The well is, of course, a wildcat and it would obviously be unwise to develop at this time extensive operations peculiar to marine drilling such as those employed in proved fields lying beneath water.

Fig. 1. Diagram showing arrangement of the equipment



Surface Equipment on Piling

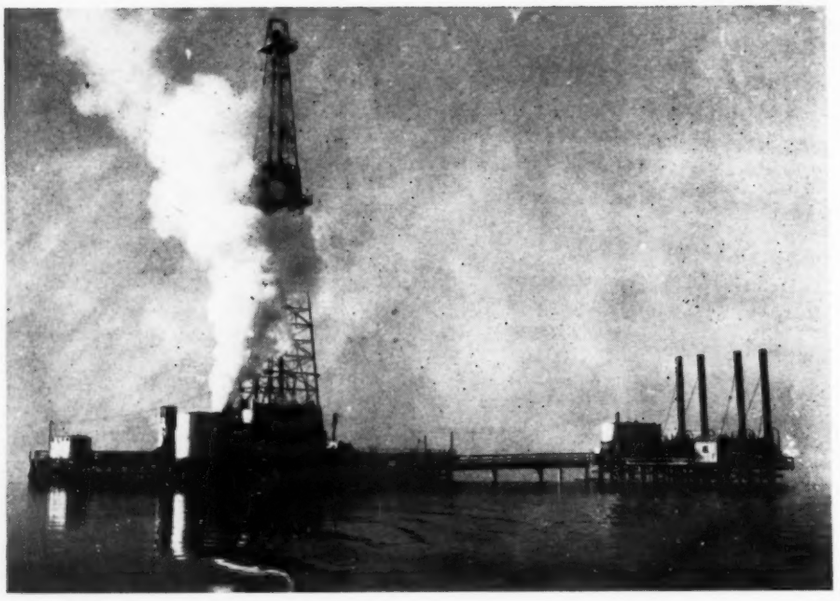
As shown in the accompanying photographs, the surface equipment being used for drilling the well is supported by wooden piles driven into the lake bed with a pile driver. The depth of water at the location is approximately 10 ft. The complete layout of the pile-supported structure is given in Fig. 1, which shows that the boiler plant is on a pier connected to the well pier by a pile-supported walkway.

As the well is to be carried to considerably below 10,000 ft., the heavy equipment previously used for drilling in one of the deeper fields in the San Joaquin Valley was moved to this location. Included is the 18-in. by 7-in. by 20-in. triplex slush pump designed for high pressure without compounding and first placed in service nearly two years ago.[1]

All structural steel trusses and members necessary for support of drawworks, engine, pipe rack, etc., were made of old salvaged pipe with welded connections and many of the trusses were brought in from other fields where they were not being used. No new steel for construction purposes could be employed. These structural trusses and members as well as floor grills, tanks, boilers, and all parts of the rig were thus adapted to the marine operation and the wooden structure was designed to utilize all equipment in the same manner as when drilling a land location.

To prevent contamination of the lake water all steam is exhausted into

[1]Described in "Three-Cylinder Slush Pump For Deep-Hole Circulation," *The Petroleum Engineer*, May, 1941.



The well and its boiler plant—three miles from shore on Tulare Lake

the tank indicated on the drawing and shown in the photographs. When this tank is to be emptied a barge is moored beside it and the sediment drained into a tank carried on the barge for the purpose. Cuttings from the shaker screen are dropped into a tank below the floor to the east of the suction tanks and indicated by broken lines on the drawing.

Equipment Transportation

As barges similar to those used in other marine drilling projects could not be obtained, eight steel pontoons that had been in service in mining operations were procured and made to provide transportation for the equipment and heavy material from the dock built on shore to the well location. These pontoons are 8 ft. wide by 36 ft. long and 40 in. deep. To make a barge for carrying the rig equipment, 8 of these pontoons were fastened side by side and on these was built a deck supported by structural steel trusses made of salvaged pipe or material previously used for floor supports at other wells. This provided a barge with overall dimensions of 36 ft. by 64 ft. and with a deck height approximately the same as that of the pier.

Another barge for carrying smaller loads that do not have to be unloaded at pier level was made with a deck built directly on the pontoons. Trucks can thus be carried across water to the location and loaded or unloaded at the well without double handling of small material and supplies. The barges are towed by a tug, whereas the personnel and small pieces of equipment, such as bits, are carried by a launch. Both boats were brought from the coast near Los Angeles.

Mud Analysis Logging

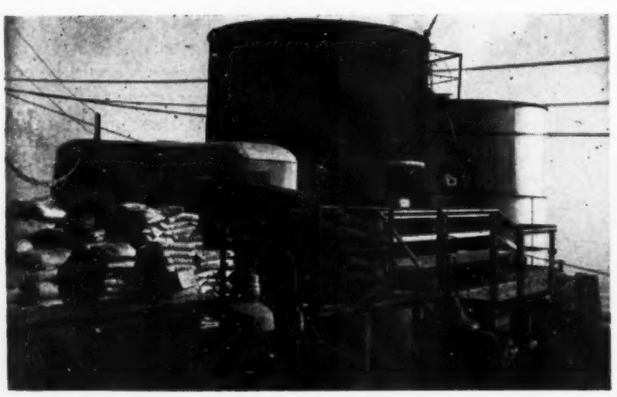
Mud analysis logging is carried on during the drilling of the well and no cores will be taken until a depth of approximately 10,000 ft. is reached. Mud for this logging service is taken from the ditch as near the wellhead as possible and pumped from there to the well-logging laboratory shown in the illustrations. The gas trap for the logging service has been placed at the same point.

As was expected in this area, gas began to show at shallow depths. Between four and five miles to the northwest of the location the Sagebrush Oil and Gas Company drilled a well that "blew in" with gas at 353 ft. This well, drilled in 1922, produced for about a week and then cratered. Several miles south of this another well was drilled at a later date and at approximately 1100 ft. picked up a light oil similar to that of Kettleman North Dome. Farther south and near the present lake shore there are some old mud volcanoes, but these are believed to be caused by marsh gas. South of the lake is the old Dudley Ridge field discovered in 1929, which was also known as the Tulare Lake field and which produced gas at approximately 1200 ft.

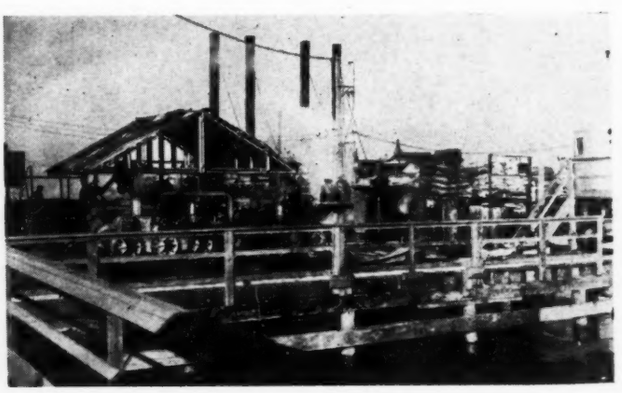
The prospects are believed to be favorable for deep production at this lake location although the structure may not be large in area. The location is evidently the result of attempts to find the deeper, smaller structures disclosed by the closer control of geophysical prospecting carried on in this part of the San Joaquin Valley.

☆ ☆ ☆

The mud analysis logging laboratory truck is set beside the mud storage tank



General view of the mud pumps and mud-mixing plant



Welded Steel Tube For Condensers and Heat Exchangers

PETROLEUM ENGINEER Exclusive Feature

☆ Electric-welded tubing to help meet heavy war demands for small steel tubing in petroleum refining operations

by A. F. Zoll

Consulting Engineer, Formed Steel Tube Institute

WITH the new construction work well under way for plants that have been planned to produce large supplies of synthetic rubber materials and aviation gasoline in 1943, considerable attention has been given to assuring an adequate supply of steel tubing for the heat exchangers these various plants will require. It is also essential to have tubing stocks available for replacements in existing petroleum plants, as the maintenance of their total production capacity is essential to the war production program.

The first important official action to provide for a continued and sufficient supply of steel tube was the issuance, on April 16, 1942, of a letter to petroleum refining officials by C. E. Adams, then Chief of the War Production Board's Iron and Steel Branch. This letter directed attention to the tremendous demand, for direct defense, for small-diameter seamless steel tubing, which had been most commonly specified for the construction of heat exchangers and condensers, and requested that electric-welded tubing be used wherever possible by the petroleum industry.

Welded tubing has not been used extensively in the petroleum industry up to the present time for several reasons. The welded tube mills have found an outlet for a very large part of their output in the automotive industries, important tonnages also going into furniture, office equipment, and other mechanical applications. About 20 companies were engaged in the manufacture of tubing and fabricated tubular parts before the war. Progress in the refinement of the manufacturing processes was rapid in the ten years preceding the war, but the volume of application in the petroleum industry was necessarily limited until a satisfactory specification for welded tube for heat-exchanger and condenser purposes could be developed. The issuance of A.S.T.M. Specification A-214 in 1939 made it permissible to use welded tubing in the construction of heat exchangers and condensers that have to meet code requirements.

Method of Manufacture

The inherent properties of welded steel tube can best be made apparent by a brief description of the method of manufacture. In the tube-forming process, flat stock is fed continuously from coils through forming rolls that gradually shape it to the form of a circle. (Figs. 1, 2, and 3). The strip stock first passes through a pair of driving rolls and then through a series of forming rolls that produce the circular cross-section. At the beginning of the operation the top and bottom forming rolls are opposite in contour, but the final forming rolls are of the same contour, top and bottom. In passing through

A. F. ZOLL

attended Washington and Lee University and Shurtleff College—In 1919 he entered the employ of Shell Oil Company—In 1923 was employed by Universal Oil Products Company—Returned to Shell Oil Company in 1927 at East Chicago refinery where he was in charge of cracking operations—Employed as superintendent of White Star Refining Company, Trenton, Michigan, in 1929—Joined National Tube Company in 1937 doing sales promotion work—February, 1942, served the War Production Board, Iron and Steel Branch, as principal industrial specialist in the Tubing Unit—November, 1942, joined the Formed Steel Tube Institute as consultant for the production of welded tubing applicable for refinery uses.

Fig. 1. A battery of electric-resistance welding tube mills. Reserve coils of flat stock are ready at each mill to facilitate continuous operation

Fig. 2. Lower section of first forming rolls. Rolls in the upper section have corresponding convex curvatures

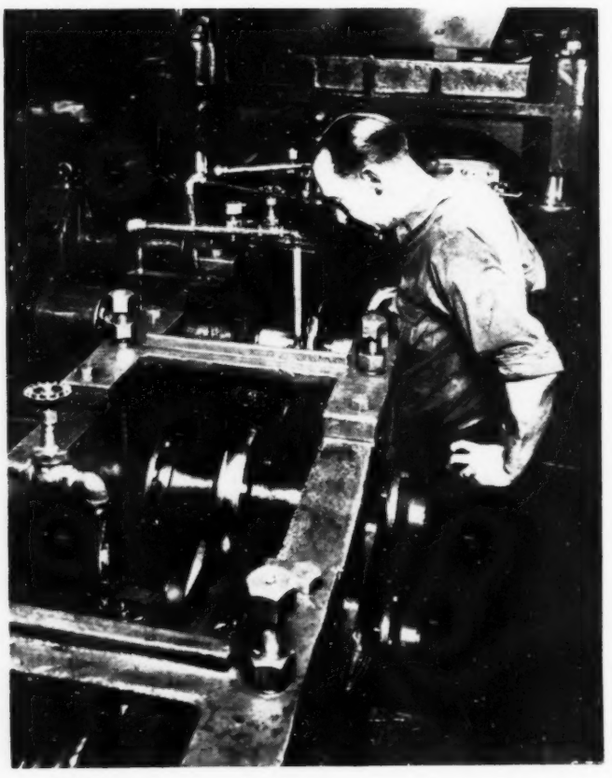


Fig. 3. Final forming rolls. From this point on roll pressure is applied from the outside only

this series of rolls, the stock is curved gradually until a circular tubular shape is obtained. Then the butted edges are welded together to make a continuous tube wall.

There are several different welding processes employed to close the seam as the edges of the strip come together. A.S.T.M. Specification A-214-40, however, covers only carbon steel heat exchanger and condenser tubing welded by the electric-resistance welding process. In this process the welding unit consists of a high amperage current supply connected to a pair of copper alloy disks, which serve as electrodes and make a rolling contact with the two edges of the formed strip. When the tubing passes under the electrodes, current is automatically applied and travels from one electrode to the other across the seam cleft, creating heat through the resistance offered to the flow of the current by the edge surfaces. (Fig. 4).

At the moment the current is applied, the side rolls exert sufficient pressure to bring the heated edges together and form a welded joint. The material at the extreme edges of the butted joints, which has been heated somewhat beyond the plastic state, is squeezed outward and the union is made with unexposed metal that is in the plastic condition.

The strip stock is generally received in coils from the steel mill where it is trimmed accurately to the width necessary for shaping to the required diameter. The process of rolling steel into coiled flat-rolled stock assures a basic high-quality material of maximum strength, accurate gauge, and excellent surface. As the tube-forming is done cold it magnifies and does not hide or heal any surface defects. Such defects can more easily be detected in the forming of welded tubing because both the inside and the outside surfaces can be inspected almost to the end of the forming operation.

Questions arise regarding the strength of the weld produced in these operations. The universal use of welded equipment in every phase of petroleum industry operations very clearly demonstrates the confidence that industry has in welded construction, and the remarkable record of lack of weld failures in this industry demonstrates in turn that this confidence is well founded. Nevertheless, it may be well to note at this point that the integrity of the weld area in welded steel tubing has been thoroughly established both by scientific investigation and by practical usage. In 1929 the U. S. Bureau of Standards made an extensive series of tests on carbon steel tubing manufactured by the electric-resistance welding process. These tests included tensile tests, axial crushing tests, torsion tests, hydrostatic pressure tests, hardness tests, flanging tests, and microscopic examination of the weld areas. The results of these tests were summarized in the conclusion that the weld is as strong as the wall and has the same qualities as the steel from which it was made, so far as strength and other physical characteristics are concerned.

Practical confirmation of the above conclusion is found in the fact that a very large proportion of the welded steel tubing normally used in industry is in the form of fabricated parts. In order to make these fabricated parts the welded tubing is subjected to severe cold-forming operations such as expanding, beading, bending, flanging, and drawing. (Figs. 5 and 6.) The ability of the weld area to withstand these operations, all of which stress the material considerably beyond the yield point, is evidence that the physical properties of the base metal are preserved and are continuous throughout the tube wall.

The method of control of weld quality in production varies according to the service for which each mill run of welded tubing is intended. In general, the procedure is to cut samples from the production at regular intervals, for making tests that will assure satisfactory performance of the tube for a particular application or for a range of applications. (Fig. 7.) Any failure occur-

ring as a result of such test is a signal to stop the mill and correct the cause of failure before resuming production. Further tests may be made of entire lengths of tubing before shipment. The nature and extent of these tests obviously will be stated in the specification, which governs the application.

In particular, the testing requirements for welded carbon steel tube manufactured for heat-exchanger and condenser purposes are described in detail in A.S.T.M. Specification A-214-40. They include a flattening test, a flanging test, a hardness test, and a hydrostatic test. It is required that one flattening test or one flaring or flanging test shall be made on each of two tubes from each lot of 250 tubes. A hardness test is required on 5 percent of all tubes. The hydrostatic test is required for each length of tube supplied for this application. The tube manufacturer, of course, has the privilege of making any additional tests he may consider advisable for the purpose of holding rejects and scrap losses to a minimum.

Returning to the discussion of the production routine, when the tube passes beyond the welding rolls it carries a very small burr or flash, which is left on the inside and outside of the tubing by the welding operation. The most common method of removing the outside flash consists of planing it off with suitable cutting tools shaped to the contour of the tubing. It is not generally necessary to remove the inside flash when the tube is to be used for heat exchangers or condensers. When special conditions do make this necessary, however, the inside flash can be smoothed down while the tubing at the welded seam is still in the plastic state, by applying planishing rolls both inside and outside the tubing, or by other suitable means.

Accurate sizing and straightening is commonly accomplished by passing the tube through a series of rolls. The tube then reaches the cut-off machine, which moves with the tubing and cuts it off to the specified length. This operation is usually such as to permit continuous operation of the entire tube-forming and welding machine. There are several methods of cutting off in common use, all of them requiring a finishing operation when a smooth end is desired, as in the case of heat-exchanger tube.

As the presence of the inside flash is objectionable because of the rolling-in operation, the flash is removed inside for a distance of approximately 4 in. at each end.

Normalizing of the tube is a requirement under A.S.T.M. Specification A-214-40, and when carried out it has the beneficial effect of improving the corrosion resistance of the weld area by relieving any residual stresses that may be present, and of equalizing the slight increase in hardness that is normally present in any untreated weld zone. Specific conditions of application govern the actual necessity for complete normalizing, there being ample service experience to show that tube in the as-welded condition gives satisfactory performance when corrosion conditions are not severe.

Each length of tube is subjected to a hydrostatic pressure test of 1000 lb. per sq. in. minimum, as mentioned. Then it is marked to show that it is pressure tubing, and after final inspection for surface finish and straightness it is packed for shipment.

Although welded tube manufacturers in general have been accomplishing a steady improvement in the quality of their product during the last ten years—indeed, a high-quality product has been necessary to permit the manufacture of many of the fabricated tubular parts that have constituted a large volume of the industry's business—very few of these manufacturers have looked to the petroleum and processing industry for an outlet. Consequently, there was until recently a limited amount of the equipment and facilities that are needed to meet all requirements of the specification for heat-exchanger and condenser tubing. This situation was in line with the demand that existed for carbon steel tubing for this application prior to the inauguration of the war production program.

During the summer of 1942 it developed that due to the nature of the processes that were to be used for the production of synthetic rubber constituents and of high octane aviation gasoline, the requirement for carbon steel tubing in small diameters for new plant construction would be multiplied several times.

Surveys of tube production facilities indicated that there was not sufficient open capacity in the seamless tube industry to take care of this demand, and that the manufacturers of welded tube, although equipped with ample welding capacity, were limited in their facilities for normalizing and for making the hydrostatic pressure test.

Proposed Modifications

In the course of a series of conferences between the welded tubing industry and the interested government bureaus it was brought out that many of the heat exchangers that were to be manufactured would operate under conditions in which satisfactory service could be obtained from welded tubing that did not meet the full requirements of Specification A-214-40 in every detail. These conferences were productive of some planning to provide a modified version of Specification A-214-40 wherever operating conditions were such that this could reasonably be done, for the

(Continued on Page 40)

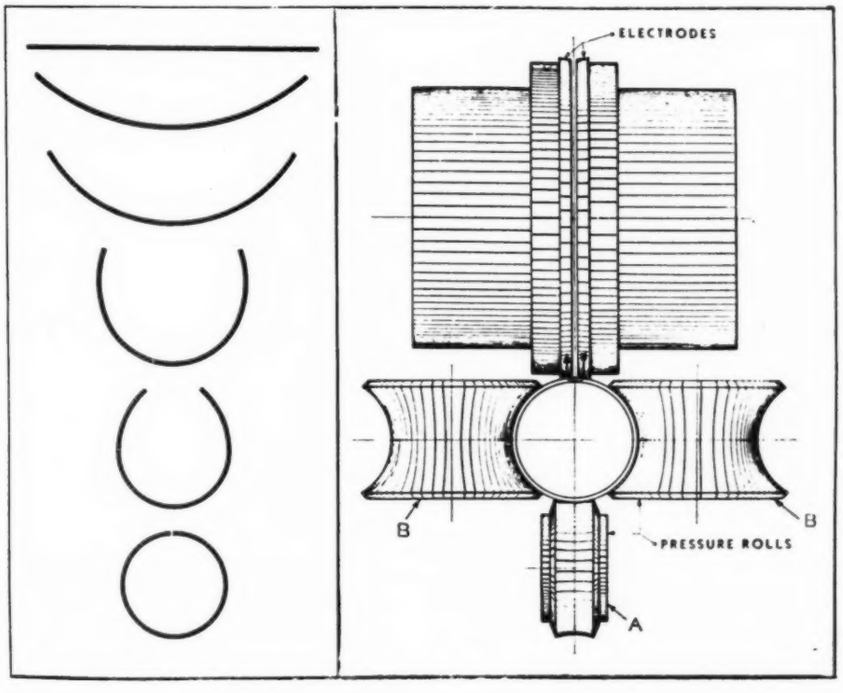


Fig. 4. Left: Method of gradually forming flat steel strip into tubular shape without undue strain on the material. Right: Electric-resistance method of welding tube. Application of rolls on both sides and beneath the electrodes that force the heated tube edges together to form a weld

For its Vital War

TYPE G·MV ANGLE

Compressor

New York Washington Bradford, Pa. Parkersburg, W. Va. Gloucester, Mass

Synthesis Plants

AMERICA PREFERS G-MV

Synthetic Rubber

•

Synthetic Ammonia

•

High-octane Gasoline

•

Toluol

•

Reforming other gases for synthetic products

To do its part in the augmented war program, Cooper-Bessemer has expanded production of the Type G-MV Compressor again and again. Noteworthy among most recent installations are two in the Gulf Coast area of 13,800 HP and 7,000 HP, respectively, and one of 24,000 in a large Midwestern plant. These G-MV's and many others are all engaged in intensive synthesis work.

Outstanding, unique design features of the G-MV which enable it to meet the severe requirement of synthesis plants are these:

1. **Stamina to stand up through long operating periods between shutdowns.**
2. **Wide speed range for process flexibility.**
3. **Six stage compression, with interstage processing.**

Every Cooper-Bessemer engine and compressor is backed by a field organization ready to serve you in every possible way.

by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

Houston, Dallas, Greggton, Pampa and Odessa, Texas Tulsa Shreveport St. Louis Los Angeles Seattle, Wash.

(Continued from Page 37)

purpose of keeping the plant construction schedule from slowing down.

One important modification proposed was the elimination of the requirement for normalizing whenever operating conditions indicated that this is permissible. In order to avoid any difficulty, due to a slight increase in hardness at the weld that might be encountered in rolling-in tubes in the as-welded condition, it was brought out that it would be relatively easy for tube manufacturers to provide facilities for annealing the ends of tubes, and that in some instances this could be done very much more quickly than would be possible by having to arrange for the construction of large furnaces for complete heat treatment.

Another proposed modification was to substitute a 100-lb. per sq. in. air test in a water or oil bath for the 1000-lb. per sq. in. hydrostatic test called for in the specification. This is proposed to apply only to heat-exchanger tubes operating under pressures no greater than 150 lb. per sq. in.

It is thought that these modifications in the heat-exchanger tube specification will make it possible to avoid a serious bottle-neck in steel tubing for heat-exchanger purposes. A still further step toward making it simpler to meet the expected demand for this material was the reduction in the number of tube sizes to be used for this purpose. In the War-time Standards for Design and Construction of Heat Exchangers recently issued by the War Production Board, the following sizes and gauges are recommended as standard for new construction where corrosion is not excessive:

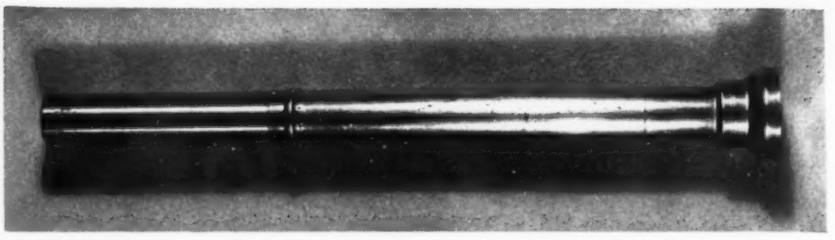


Fig. 6. This close up of one of the parts shown in Fig. 5 illustrates a typical beading operation on a fabricated part

O.D. tube, in.	*Steel thickness*
⅝	16 BWG avg. wall
¾	16 BWG avg. wall
1	16 BWG avg. wall
1¼	14 BWG avg. wall

Fig. 7. Typical routine test specimens. 1. Crush test, welded stainless steel tube. 2. Flattening test, carbon steel tube. 3. Expanding and flanging test, carbon steel tube. 4. Crush test, carbon steel tube, sectioned to show extent of deformation

When excessive corrosion and erosion is definitely expected, upon presentation of conclusive evidence of necessity, and approval by the War Production Board, sizes may be selected from the following:

O.D. tube, in.	*Steel thickness*
⅝	16 BWG avg. wall
¾	14 BWG avg. wall
1	13 BWG avg. wall
1¼	11 BWG avg. wall

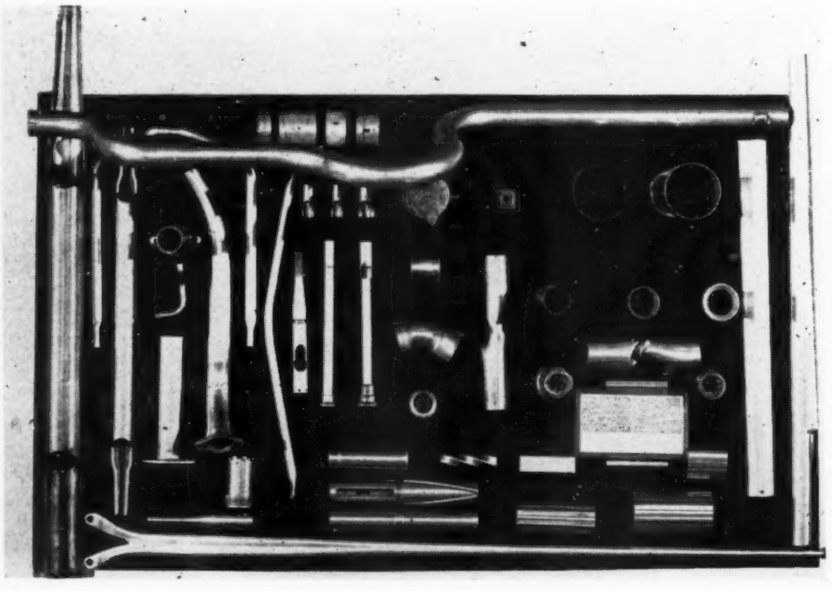
Standard overall tube lengths for straight tube units are: 8, 12, 16, 20, and 24 ft.

The foregoing discussion is intended to explain to the refinery engineer that welded heat-exchanger tube is not an emergency substitute, but rather an ideal product for this application. The material is carefully selected for the purpose and the manufacturing process is subject to precise control from start to finish. Due to the uniformity of wall thickness throughout the entire tube the inside diameter and outside diameter are concentric. This permits the use of minimum gauges in design with resultant savings in fabricating costs and in weight.

Until such time as all manufacturers of welded tube who produce heat-exchanger tubing complete the installation of facilities needed for normalizing and hydrostatic testing, the procurement of this tubing both for new construction and replacement will obviously be expedited by accepting the recommended modifications to the specification whenever operating conditions permit. Earlier deliveries can also be expected on the sizes that have been designated as standard, especially in the case of relatively small quantities that ordinarily are purchased from warehouse stocks. Reasonable conformity to these suggestions will certainly go far toward avoiding anything resembling a shortage of steel tubing for these uses.

☆ ☆ ☆

Fig. 5. A collection of fabricated tubular parts and routine test specimens, illustrating typical cold-forming operations commonly performed on welded steel tubing



Hydrocarbons in Petroleum

☆ Some Results of A.P.I. Research Project 6

PETROLEUM ENGINEER EXCLUSIVE Feature

by Frederick D. Rossini

Chief of the Section on Thermochemistry and Constitution of Petroleum, National Bureau of Standards

Introduction

A COMPREHENSIVE investigation on the isolation and identification of hydrocarbons in petroleum was begun in 1927 at the National Bureau of Standards under the direction of Edward W. Washburn. This work, sponsored jointly by the American Petroleum Institute and the National Bureau of Standards, has been carried on as the A.P.I. Research Project 6. The investigation has to date involved a total of about 140 man-years of research and has resulted in the separation of 69 hydrocarbons from petroleum. The methods and apparatus used for fractionating and isolating the hydrocarbons, and for determining their properties and purity, are described in 80 publications* by 14 different investigators.

At the present time, the staff of the Project consists of five research chemists (B. J. Mair, C. B. Willingham, A. R. Glasgow, Jr., A. J. Streiff, and A. F. Forziati), six laboratory assistants, and the supervisor, in which latter capacity the writer has served since the death in 1934 of Doctor Washburn. To advise the Project in its work, the American Petroleum Institute has a special committee consisting of J. Bennett Hill, Sun Oil Company, chairman, William J. Sweeney, Standard Oil Development Company, and Seymour W. Ferris, Atlantic Refining Company. This committee acts as a subcommittee of the Institute's main Advisory Committee on Fundamental Research on the Composition and Properties of Petroleum, of which J. Bennett Hill is chairman and R. P. Anderson secretary.

Before the beginning of this work, the existing knowledge of the hydrocarbons in petroleum (especially of molecules containing more than five carbon atoms) was relatively meager, and divergent with respect to the purposes for which the studies had been made. Because a knowledge of the chemical constitution of its raw material is fundamental to the entire petroleum industry, it was evident that such knowledge could best be ascertained in united effort. The resources made available for this work by the American Petroleum Institute and the National Bureau of Standards were merged into the A.P.I. Research Project 6, which was to carry on the fundamental work, leaving the competitive research and development units of the industry to make practical application of the basic knowledge and data obtained.

FREDERICK D. ROSSINI

received his B. S. and M. S. degrees from Carnegie Institute of Technology, attending from 1921 to 1926, and his Ph. D. from the University of California in 1928—He has held research positions with the National Bureau of Standards as assistant scientist in physical chemistry from 1928 to 1929 and as associate scientist in physical chemistry from 1929 to 1936—Since 1936 has been chief of the Section on Thermochemistry and Constitution of Petroleum—During his academic and research career he has done part time teaching at Carnegie Institute of Technology, University of California, National Bureau of Standards Educational Committee, Howard University, and the Catholic University of America—Is a member of the Washington Academy of Sciences, New York Academy of Sciences, American Chemical Society, American Physical Society, American Association for the Advancement of Science, Philosophical Society of Washington, and American Petroleum Institute—He is a member of the permanent committee on thermochemistry of the International Union of Chemistry—Was editor of the Journal, 1937-39, and secretary, 1940-42, of Washington Academy of Sciences, and a member of the committees on thermal data for industry, data for ceramic substances, and fundamental physical constants of the National Research Council—The Hildebrand Award for 1934 was presented to him by the Chemical Society of Washington—Publications include 55 journal papers and one book with F. R. Bichowsky, "Thermochemistry of the Chemical Substances."

The purpose of the present article is to give a brief account of the work of the A.P.I. Research Project 6 and to summarize the results obtained on one Mid-Continent petroleum. With regard to the problem of how the amounts of the various hydrocarbon components vary from crude to crude, our present knowledge is based largely upon the extensive work done by M. R. Fenske and associates at the Petroleum Refining Laboratory of Pennsylvania State College. One of their investigations, carried on in collaboration with the Standard Oil Development Company, yielded results on 20 virgin naphthas from various parts of the world.† About a year ago, the A.P.I. Research Project 6 began a new investigation on the analysis of the gasoline fraction of representative crude petroleums, which will give more detailed information on the problem.‡

General Method of Operation

Substantially all the hydrocarbons in petroleum are composed of paraffin groups, cycloparaffin or naphthene groups, aromatic groups, mixed aromatic-naphthene groups, or combinations of these. No olefin or acetylene hydrocarbons appear to be in naturally-occurring petroleum in any significant amount.

The problem assigned to the Project was that of separating, without altering the constituents, the complex mixture of hydrocarbons that constitute petroleum, and, beginning with the low-boiling end, to obtain the major components in a substantially pure state. To do this has required continued improvement and development of

*See the list of publications of the A.P.I. Research Project at the end of the article. References to these publications are made in this article by reference numbers.

†See C. O. Tongberg, M. R. Fenske, and W. J. Sweeney. *Ind. Eng. Chem. 30*, 166 (1938), and also Fig. 3 in Paper No. 57 of the A.P.I. Research Project 6.

‡See the paper by F. D. Rossini, B. J. Mair, A. F. Forziati, A. R. Glasgow, Jr., and C. B. Willingham, entitled "Method for Analyzing the Gasoline Fraction of Petroleum with Preliminary Results on East Texas and Oklahoma Crudes", presented at the Annual Meeting of the American Petroleum Institute, November, 1942.

methods and apparatus for fractionating hydrocarbons and for determining their properties and purity.

The general method of operation is to utilize the various processes of fractionation in such combinations as will produce a "sifting" of the molecules with respect to size on the one hand and to type on the other.

Processes of Fractionation

To be successful in separating a given mixture of hydrocarbons, any process of fractionation must be one that involves a physical property that has significantly different values for the several components of the mixture to be separated. Furthermore, the procedure must be one for which there is available, or can be developed, a workable apparatus.

The standard processes of fractionation used in this work are those of distillation, extraction, adsorption, and crystallization, which involve the properties of vapor pressure (or boiling point), solubility, adsorbability, and freezing point. The following variations of these processes are used:

I. *Distillation*
   1. At one fixed pressure.
   2. Alternately at two fixed pressures.
   3. With an azeotrope-forming substance.

II. *Extraction*
   1. With different solvents.
   2. At different temperatures.

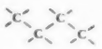
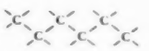
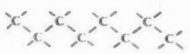
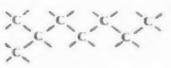
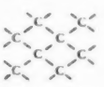
III. *Adsorption*
   1. With different adsorbents.
   2. At different temperatures.

IV. *Crystallization*
   1. From the mixture of hydrocarbons, with centrifuging.
   2. From a solution of the hydrocarbons in an appropriate solvent, with centrifuging.

With regard to the nature of the separation obtained, the foregoing processes of fractionation, excluding crystallization, may be classified according to whether they fractionate primarily with respect to size of molecule or to type of molecule. Separation primarily according to size of molecule (or boiling point or molecular weight) is produced by distillation at one fixed pressure. Separation primarily according to type of molecule is produced by distillation alternately at two fixed pressures, by distillation with an azeotrope-forming substance, by extraction, and by adsorption. In connection with separations by type, it is important to note (see later) that, except in certain special cases, both alternate distillation at two fixed pressures and distillation with an azeotrope-forming substance require a charging stock that is homogeneous with respect to boiling point (or size of molecules), that is, a relatively narrow-boiling charge. On the other hand, the process of extraction may be used successfully on rather wide-boiling charges, and the process of adsorption may be used on extremely wide-boiling material.

TABLE 1

Relationship between freezing point and size and symmetry of hydrocarbon molecules

Compound	*Formula*	*Skeleton structure*	*Freezing point, °C.*
Ethane	C_2H_6		— 183
n-Butane	C_4H_{10}		— 135
n-Hexane	C_6H_{14}		— 95
n-Octane	C_8H_{18}		— 57
2-Methylheptane	C_8H_{18}		— 110
Hexamethylethane	C_8H_{18}		+ 102

In connection with separation by crystallization, two general statements may be made regarding hydrocarbons: (a) for a given degree of symmetry of the molecule, the freezing point usually is higher the greater the size of the molecule, as illustrated by the first four compounds listed in Table 1; (b) for a given number of carbon atoms in the molecule, the freezing point usually is higher the greater the symmetry of the molecule, as illustrated by the last three compounds in Table 1.

Except for those few hydrocarbons in the volatile range that have boiling points relatively far from their neighbors, and except for certain other hydrocarbons present in relatively large amount (as normal paraffins in a Pennsylvania or a Mid-Continent petroleum), regular distillation alone will not separate pure hydrocarbons from petroleum, and one or more of the other methods (including the variations of distillation) must also be used. The order in which the several methods are used is determined by the effectiveness of a given process in increasing the separation attained by the preceding method. Thus, although a given process may be ineffective when used alone, its systematic use in appropriate combination with other processes can often lead to the complete separation of an otherwise unseparable constituent.

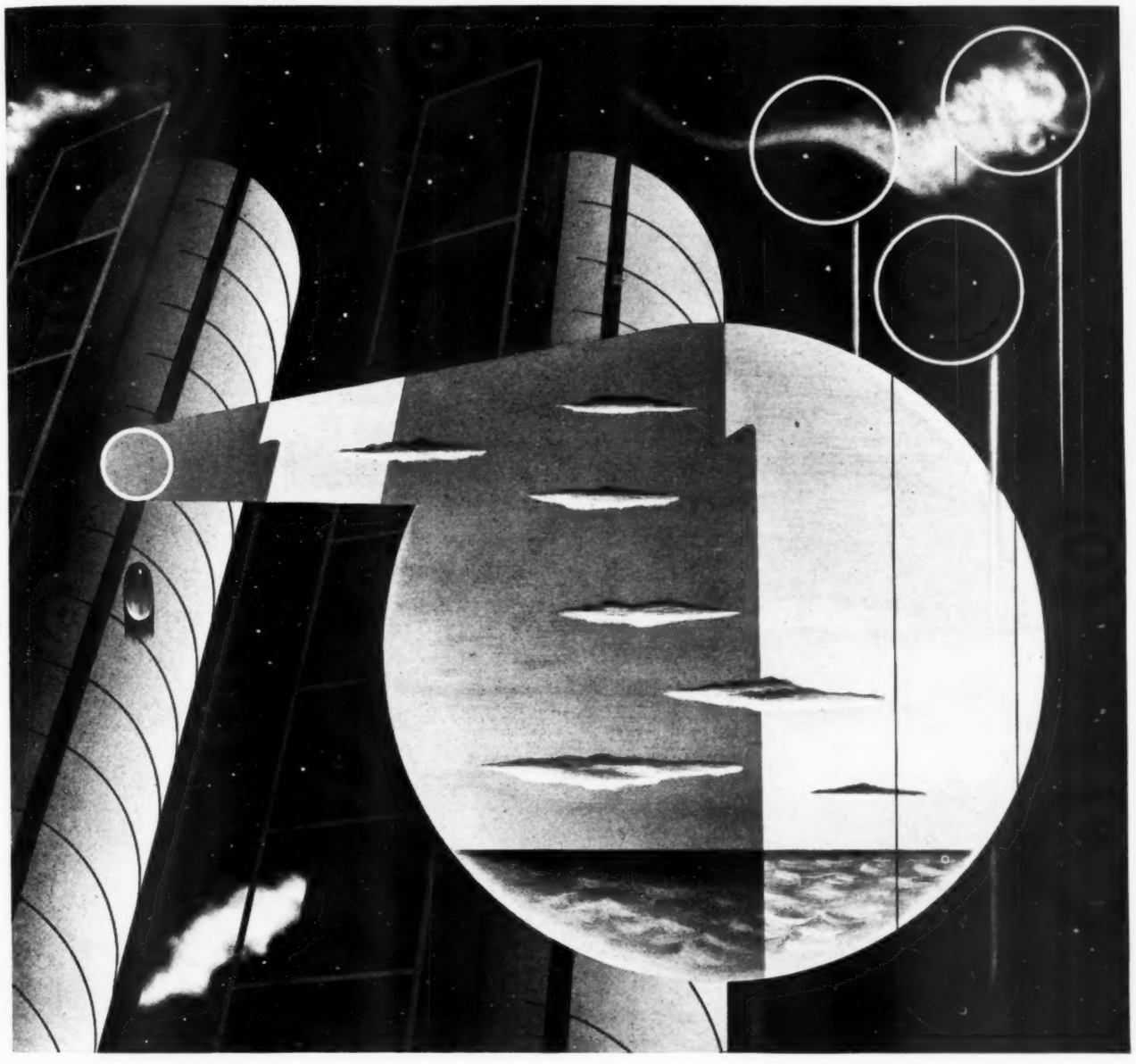
Distillation

Distillation is the most important fractionating process for separating hydrocarbons of the gasoline and kerosine fractions of petroleum. This is because distillation can separate either by size or by type of molecule, according to whether one operates at a fixed pressure on the one hand, or alternately at two fixed pressures or with an azeotrope-forming substance on the other hand. For each of the several kinds of distillation, the same rectifying columns may be used, with substantially the same procedure.

TABLE 2

Approximate minimum number of theoretical plates required in a distillation column to produce, from an equimolal mixture of A and B, the more volatile hydrocarbon A in given degrees of purity, when A and B are average hydrocarbons of the gasoline range having differences in boiling point as indicated

Difference in normal boiling points of A and B, °C.	Composition				Approximate minimum number of theoretical plates required
	Pot		Head		
	A	B	A	B	
	mole	fraction	mole	fraction	
4	0.50	0.50	0.90	0.10	20
4	0.50	0.50	0.99	0.01	40
4	0.50	0.50	0.999	0.001	60
2	0.50	0.50	0.90	0.10	40
2	0.50	0.50	0.99	0.01	80
2	0.50	0.50	0.999	0.001	120
1	0.50	0.50	0.90	0.10	80
1	0.50	0.50	0.99	0.01	160
1	0.50	0.50	0.999	0.001	240



It's already Day after Tomorrow!

Under the stinging lash of a war for survival, American chemists are fighting fantastic battles . . . cramming a year's progress into a day . . . drawing up, in advance, the pattern of things to be.

For this is the new, stupendous era of synthetics. Already scientists are talking about glass that will float, wood that won't burn, window screens without wire, machinery bearings without metal.

Badger—with its engineers, chemists, draftsmen, designers, construction workers—is helping in this effort to save America now, to enrich her later on.

Among its many war jobs, Badger is building plants and equipment for the manufacture of butadiene and other materials required to make artificial rubber. It is building plants for producing acetic acid and phthalic anhydride used in the manufacture of plastics for airplanes. It is building T.N.T. plants, erecting huge refineries for the production of high-octane aviation gasoline.

Miracles are being performed in the petro-chemical industries today. For obvious reasons, they can't be talked about in detail. But they do send this message to every American: Win this war—and the dawn will break on a world more wonderful than you have ever known.

LICENSING AGENTS FOR THE HOUDRY CATALYTIC CRACKING PROCESSES

E. B. Badger & SONS CO., BOSTON · EST. 1841

NEW YORK · PHILADELPHIA · SAN FRANCISCO · LONDON

PROCESS ENGINEERS AND CONSTRUCTORS FOR THE PETRO-CHEMICAL INDUSTRIES

In the distillation laboratory of the A.P.I. Research Project 6 at the National Bureau of Standards there are 10 to 12 rectifying columns in continuous operation, 24 hours a day, seven days a week. These columns have separating efficiencies equivalent to from 100 to 150 theoretical plates, and are usually operated with reflux ratios from 100 to 1 up to 200 to 1, with a rate of removal of distillate of from 1 to 12 ml. of liquid per hour. The volume of the material charged in a still may vary from 200 to 7000 ml., and the time of distilling a charge may vary from 6 to 60 days of continuous operation, 24 hours a day.

In this group of distillation columns, the rectifying section proper varies from ⅜ to 1 in. in diameter and from 6 to 9 ft. in length. Distillation of material of the gasoline and kerosine ranges is performed at one of three fixed pressures, which are controlled automatically at 770, 217, and 56.8 mm. Hg. The first pressure was selected so as to be always above the prevailing atmospheric pressure, and the second and third pressures were arbitrarily selected so as to produce successive lowerings of about 450°C. in the boiling point of material of the gasoline and kerosine ranges. Except in unusual cases, distillation temperatures for material of the gasoline and kerosine ranges are never permitted to go above about 175°C.

In connection with the requirement regarding the number of theoretical plates needed for a given distillation, Table 2 gives some approximate values of the minimum number of theoretical plates necessary to produce, from an equimolal mixture of hydrocarbons A and B, the more volatile hydrocarbon A in a purity of 0.90, 0.99, and 0.999 mole fraction, respectively, when A and B are average hydrocarbons of the gasoline range having differences in normal boiling point equal to 4, 2, and 1°C.

Distillation Alternately at Two Fixed Pressures

When a mixture of hydrocarbons contains components that have substantially the same boiling point at the normal distilling pressure but significantly different boiling points at a different pressure, the separation of such components can be effected by distilling the mixture alternately at the two pressures. When the pressure is lowered from 760 to 100 mm. Hg., the corresponding lowering of the boiling point for given types of hydrocarbons of the gasoline and kerosine ranges is greater than that of a normal paraffin of the same boiling point at 760 mm. Hg. by

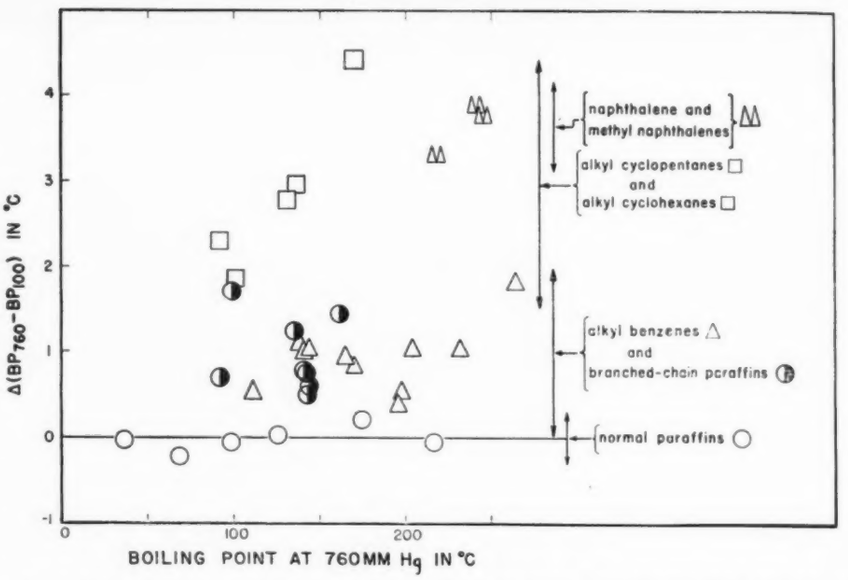
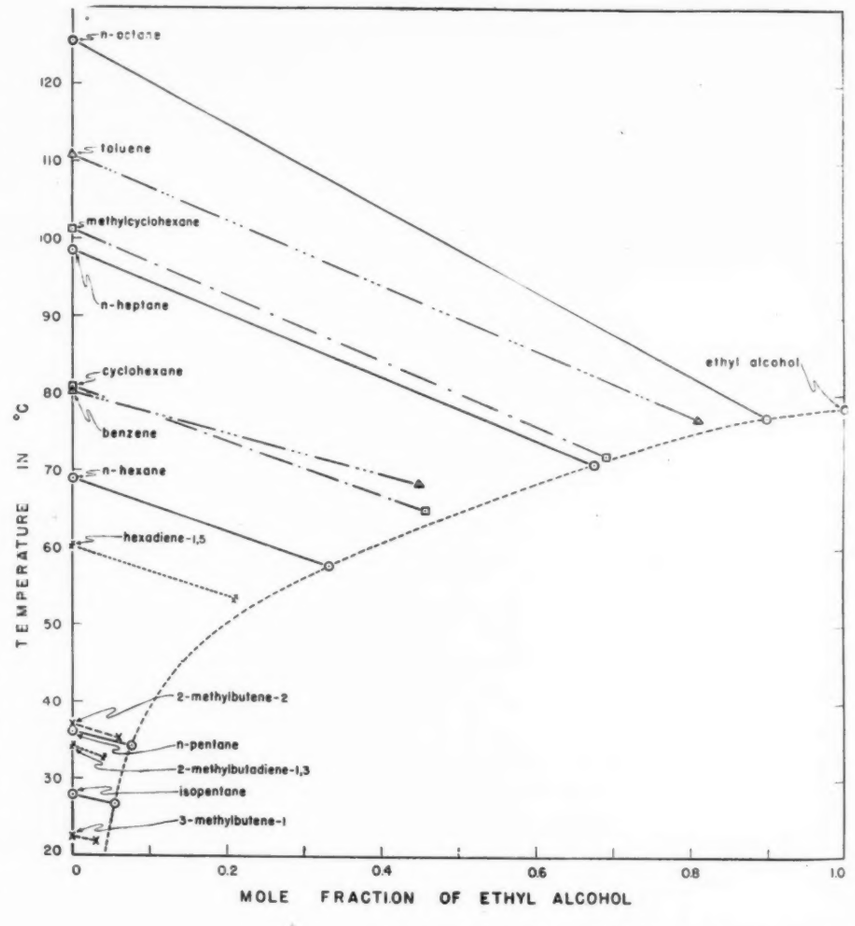

naphthalene and methyl naphthalenes
alkyl cyclopentanes and alkyl cyclohexanes
alkyl benzenes and branched-chain paraffins
normal paraffins
Δ(BP760−BP100) IN °C
BOILING POINT AT 760MM Hg IN °C

Fig. 1. Difference in the change of boiling point with pressure for several types of hydrocarbons. The scale of abscissas gives in °C. the value of the boiling point of the given hydrocarbon at 760 mm. hg. The scale of ordinates gives in °C. the value of

$$\Delta\ (BP_{760} - BP_{100}) = (BP_{760} - BP_{100}) - (BP_{760} - BP_{100})_{n\text{-paraffin}}$$

that is, the excess lowering of the boiling point of a given hydrocarbon over that of a hypothetical n-paraffin of the same boiling point at 760 mm. hg. as the pressure is lowered from 760 to 100 mm. hg.[22]

Fig. 2. Plot of the values of the boiling point and composition of the binary azeotropic mixtures formed between ethyl alcohol and some paraffin, naphthene, olefin, and aromatic hydrocarbons, together with the boiling points of the pure components. The scale of ordinates gives the temperature in °C., and the scale of abscissas gives the mole fraction of ethyl alcohol in the respective azeotropic mixtures. The straight lines are drawn to join the boiling point and composition of the azeotropic mixture with the boiling point of the corresponding hydrocarbon in the pure state. The curved dashed line gives the loci of points representing azeotropic mixtures of ethyl alcohol with paraffin hydrocarbons[22]



WeldELLS

have everything

. . One of the things that speeds up the job and makes it better

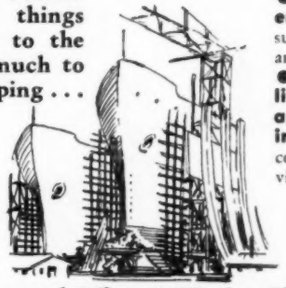
• Naturally any welder will work both faster and better when he works with fittings that are designed to help him do *his* part right. And you'll find welders pretty well agreed that WeldELLS offer more to the man on the job than any other.

A good example of this—a feature that is found only in WeldELLS—is illustrated above. These precision quarter-markings at each end of every WeldELL make it easy to establish center lines and follow planes. It's typical of the many features, listed opposite, that give the welder a real incentive to do a better job.

The features of WeldELLS that contribute to sound engineering design is still another story—told briefly in the listing, and eloquently by the preference of engineers. But do not forget that the things which mean so much to the welder, mean just as much to the man who designs piping . . . or pays for it.

Products vital to modern warfare

The list of Taylor Forge's contributions to the war effort only begins with WeldELLS. Every Taylor Forge product is playing a vital part. One of many examples is Forged Steel Welding Nozzles, essential to hundreds of transports and fighting ships.



No other fittings for pipe welding combine the features found in WeldELLS which, in addition to quarter-markings, include:

● **Seamless** — Greater strength and uniformity.
● **Tangents**—Keep weld away from zone of highest stress—simplify lining up.
● **Selective reinforcement** — provides uniform strength.
● **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.
● **Wall thickness never less than specification minimum** — assures full strength and long life.
● **Machine tool beveled ends**—provide best welding surface and accurate bevel and land.
● **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

TAYLOR FORGE & PIPE WORKS, General Offices & Works: Chicago, P. O. Box 485

NEW YORK OFFICE: 50 CHURCH STREET • PHILADELPHIA OFFICE: BROAD STREET STATION BLDG.

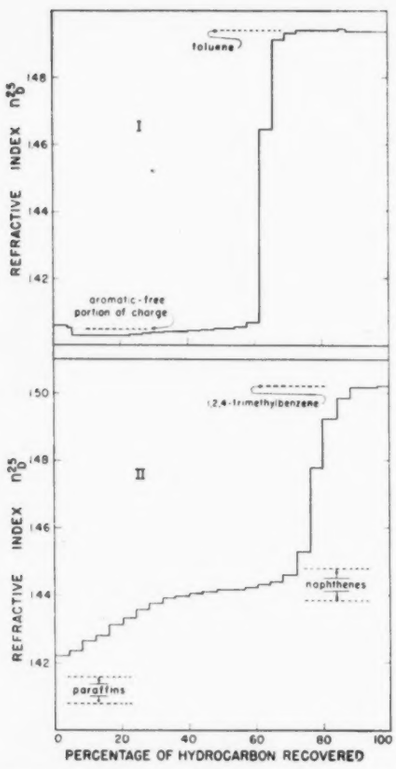


Fig. 3. Diagrams illustrating the separation of aromatic, naphthene, and paraffin hydrocarbons by azeotropic distillation. The scale of ordinates gives the refractive index of the hydrocarbon recovered from the azeotropic distillate, and the scale of abscissae gives the percentage of the hydrocarbon recovered. The distillations were performed in a Bruun glass bubble-cap column of about 100 theoretical plates, with a reflux ratio of about 50 to 1. Part I shows the results of the azeotropic distillation, with methyl cyanide at atmospheric pressure, of a mixture of toluene (boiling point 110.6°C.) with a narrow-boiling (110.0° to 110.5°C.) mixture of paraffins and naphthenes. The azeotropic distillate was by volume about 20 percent of hydrocarbon for the aromatic and about 25 percent for the paraffins and naphthenes. Part II shows the results of the azeotropic distillation, with ethylene glycol monobutyl ether at 770 mm., of the mixture of aromatic, napthene, and paraffin hydrocarbons naturally occurring in a narrow-boiling (166° to 169°C.) fraction of Mid-Continent petroleum. The azeotropic distillate was by volume about 60 percent of hydrocarbon, increasing from aromatic to naphthene to paraffin

the following amounts: normal paraffins, 0°C.; *iso*paraffins, 0 to 2½°C.; cycloparaffins (naphthenes), 1½ to 4½°C.; alkyl benzenes, 0 to 2°C., and alkyl naphthalenes, 3 to 4°C. These relationships are illustrated graphically in Fig. 1 for those hydrocarbons for which data are available.[77] The foregoing differences in boiling point, although not large, are sufficient to permit a good separation in distillation columns of 100 or more theoretical plates (see Table 2).

As can be seen from the relationships given, and from the fact that (see later) other processes are available for easily separating aromatics from paraffins and naphthenes (cycloparaffins), the great usefulness of the process of distilling alternately at two fixed pressures lies in the separation of paraffins from naphthenes, and in separating dinuclear aromatics from mononuclear aromatics.

Azeotropic Distillation

When a substantially constant-boiling mixture of hydrocarbons contains components whose vapor-pressures are affected differently by the addition of a non-hyrdocarbon compound, the distillation of this mixture after the addition of the non-hydrocarbon compound will serve to separate the hydrocarbon components. In general, the added non-hydrocarbon compound will be a polar organic compound (of about the same boiling point as the hydrocarbons), which has the ability to form with each of the hydrocarbons a binary minimum constant-boiling (or azeotropic) mixture. The consequent lowering in boiling point will be greatest for the paraffin component, next greatest for the naphthene or cycloparaffin component, with the mononuclear aromatics and dinuclear aromatics following in that order. For example, consider three hydrocarbons of different types normally boiling near the same temperature, as the following:

Compound	*Type*	*Normal boiling point, °C.*
Benzene	aromatic	80.1
Cyclohexane	naphthene (cycloparaffin)	80.8
2,4-Dimethyl pentane	paraffin	80.8

One finds that ethyl alcohol, whose normal boiling point is 78°C., forms with each of these three hydrocarbons a minimum-boiling azeotropic mixture, as follows:

Mixture	*Type of hydrocarbon*	*Boiling point, °C.*
Benzene and ethyl alcohol	aromatic	68
Cyclohexane and ethyl alcohol	naphthene	64
2, 4-Dimethylpentane and ethyl alcohol	paraffin	62

Aromatic hydrocarbons may be separated from paraffins and naphthenes (cycloparaffins) with relative ease by azeotropic distillation, whereas the separation of paraffins from naphthenes is more difficult.

Fig. 2 illustrates the relationships of boiling point and composition for the binary azeotropic mixtures formed between ethyl alcohol and a number of paraffin, naphthene, olefin, and aromatic hydrocarbons and shows how the composition of the azeotropic mixture changes with the boiling point of the members of a given homologous series of hydrocarbons.[77] Data are given for *iso*pentane, *n*-pentane, *n*-hexane, *n*-heptane, and *n*-octane of the paraffins, for cyclohexane and methylcyclohexane of the naphthenes, for 3-methylbutene-1 and 2-methylbutene-2 of the monoolefins, for 2-methylbutadiene-1, 3 and hexadiene -1, 5 for the diolefins, and for benzene and toluene of the aromatics. When the boiling point of the hydrocarbon is considerably below that of the azeotrope-forming substance, the composition of the azeotropic mixture will be high in the given hydrocarbon, as shown for the two pentanes and the two pentenes. As the boiling point of the hydrocarbon rises, the boiling point of the azeotropic mixture, always below that of the hydrocarbon, moves toward the boiling point of the pure azeotrope-forming substance, and the composition of the azeotropic mixture likewise becomes leaner in hydrocarbon, with both the boiling point and the composition approaching those of the pure azeotrope-forming substance as a limit. As this is the general behavior of such systems, the dashed line, giving the loci of the points representing the boiling point and composition of the binary azeotropic mixtures of ethyl alcohol with the paraffin hydrocarbons listed, can be used to estimate the boiling point and composition of binary azeotropic mixtures of ethyl alcohol with other paraffin hydrocarbons of known boiling point for which no data on

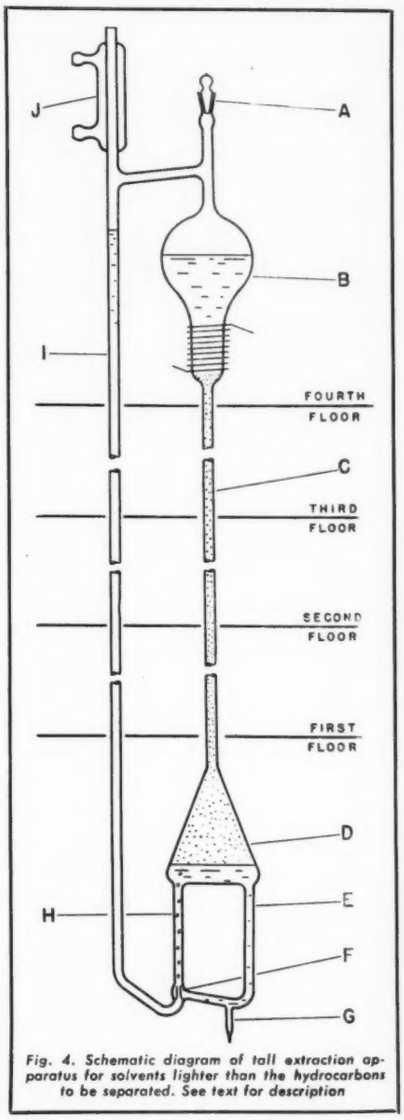
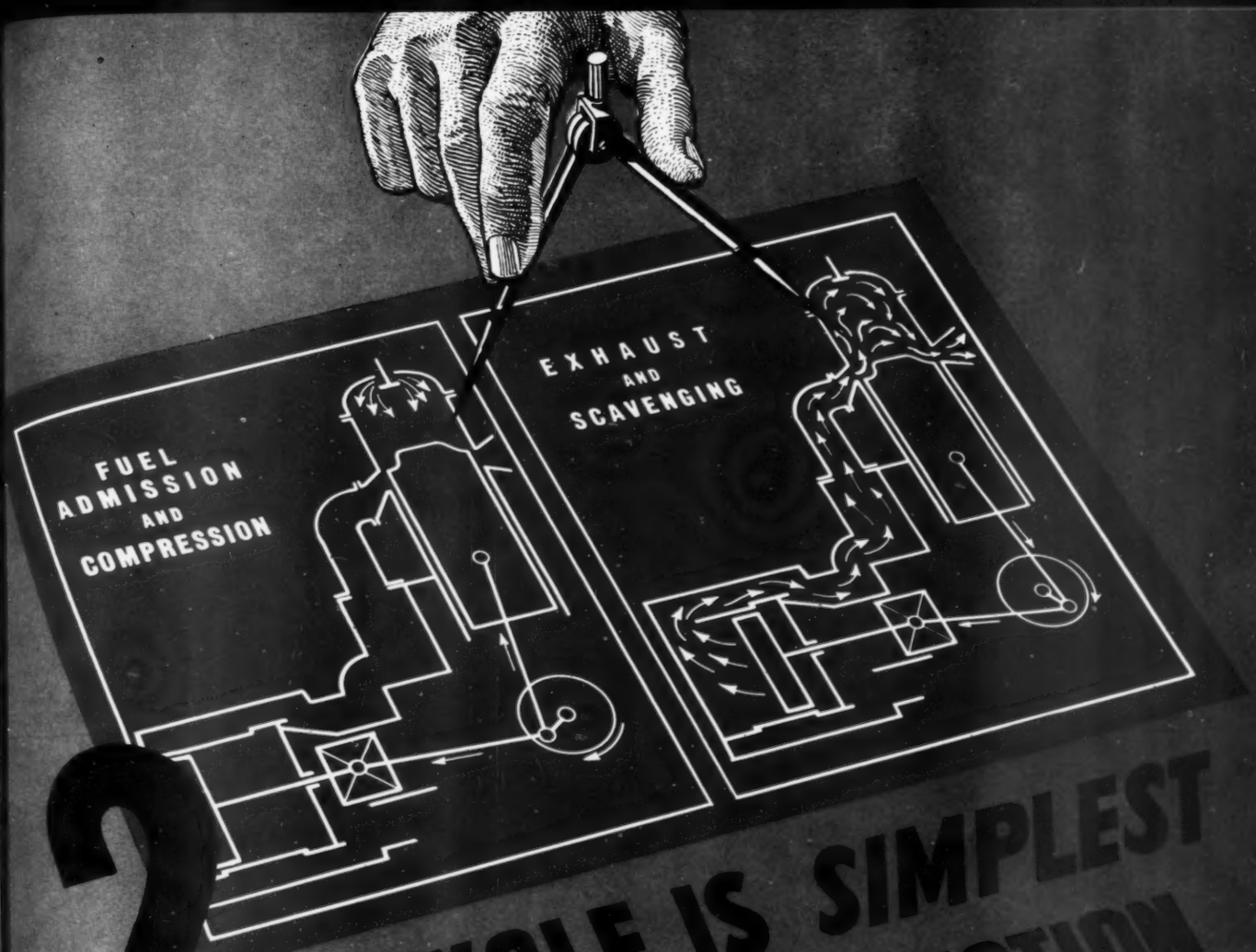


Fig. 4. Schematic diagram of tall extraction apparatus for solvents lighter than the hydrocarbons to be separated. See text for description



2-CYCLE IS SIMPLEST ENGINE CONSTRUCTION

NO VALVES TO GRIND

Simplicity of design — few moving parts — are tremendous advantages in mechanical equipment. The 2-cycle engine possesses these great advantages over the 4-cycle. It has an uninvolved fuel injection system — no exhaust valves: it represents the extreme of simplicity in operating principle.

Note the simplicity of CLARK Super-2-Cycle operation, diagramed above. Every up-stroke compresses a fuel mixture. Every down-stroke is a power stroke. There is no "waste stroke", to cut power in half and double wear and tear. Scavenging with 26% excess air is instant and thorough.

Other basic advantages in the CLARK 2-Cycle are: 1. Greater Fuel Economy; 2. Less Wear; 3. Smoother Operation; 4. Fewer Man Hours; 5. Lower Oil Consumption; 6. Lower Installation Cost.

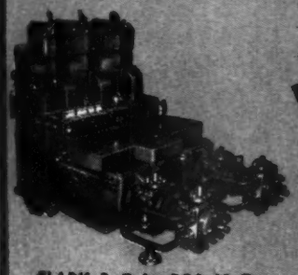
Investigate these claims. Our engineers are at your call.

CLARK BROS. CO., INC. . . . . OLEAN, NEW YORK, U.S.A.

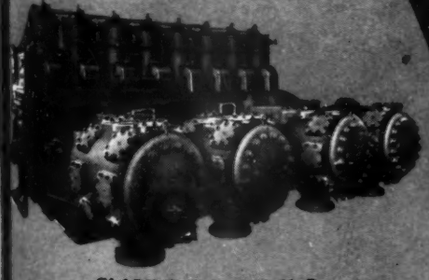
Export Office: 30 Rockefeller Plaza, New York. Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Tex.; Chicago, Ill. (122 S. Michigan Ave.); Boston, Mass. (131 Clarendon St.); Huntington Park, Calif. (5715 Bicket St.) Foreign Offices: 72 Turnmill St., E. C. 1., London; Avda Roque Saenz Pena 832, Buenos Aires.

AFFILIATED COMPANIES: Dresser Mfg. Co., Bradford, Pa.; Pacific Pump Works, Huntington Park, Calif.; Bryant Heater Company, Cleveland, Ohio.

CLARK
Super-2-Cycle



CLARK 3-Cyl., 300 H. P.
"Super-2-Cycle"
Angle Compressor



CLARK 8-Cyl., 800 H. P.
"Super-2-Cycle"
Angle Compressor

azeotropic mixtures exist. It will be noted that the points for the other hydrocarbons fall above the line for the paraffin hydrocarbons approximately in the order naphthene, monoolefin, diolefin, and aromatic. It appears that, with a given azeotrope-forming substance, all hydrocarbons of about the same boiling point will form azeotropic mixtures having roughly the same composition in terms of mole fraction of the azeotrope-forming substance, and that the boiling points of these same azeotropic mixtures usually will fall in the order aromatic, diolefin, monoolefin, naphthene, and paraffin. The same general relationships hold for the hydrocarbons with other azeotrope-forming substances.

In the work of the A.P.I. Research Project 6 on the separation of hydrocarbons by azeotropic distillation on a laboratory scale, it is usually required of an azeotrope-forming substance that it (a) have a boiling point near (not more than 30 or 40°C. away from) the boiling range of the hydrocarbons to be separated; (b) be completely soluble in water and preferentially less soluble in the hydrocarbon at room temperature, in order that the removal of the azeotrope-forming substance from the hydrocarbon with which it is associated in the azeotropic distillate may be accomplished easily by extraction with water; (c) be completely soluble in the hydrocarbon at the distillation temperature, and for some degrees below this, in order that two phases shall not form in the condenser and reflux regulator and thus cause difficulty in the operation of the latter, and, where packed instead of bubble-cap columns are used, in order that the liquid phase in the rectifying section shall be entirely homogeneous, thus avoiding the possibility of irregular segregation of two liquid phases in the packed section; (d) be readily obtainable in a sufficiently pure state at reasonable cost; and (e) be nonreactive with hydrocarbons or with the material of which the still is constructed.

Among the large number of substances that are available for use in the azeotropic distillation of hydrocarbons, those that have been used in this laboratory include the following compounds, which boil (as pure substances) approximately at the temperatures given:

Compound	*Boiling point at 1 atm.*
Methyl alcohol	66
Ethyl alcohol	78
Methyl cyanide	82
Acetic acid	118
Ethylene glycol monomethyl ether	125
Ethylene glycol monoethyl ether	135
Ethylene glycol monomethyl ether acetate	144
Ethylene glycol monobutyl ether	171
Diethylene glycol monomethyl ether	194

In preparing for the separation of the hydrocarbons occurring in any given fraction of petroleum, it is necessary to have the mixture of hydrocarbons well separated by a systematic and efficient distillation into a series of substantially constant-boiling fractions prior to the azeotropic distillation. This is necessary in order to avoid having any paraffins mixed with lower-boiling naphthenes and, in turn, any paraffins and naphthenes mixed with lower-boiling aromatics, which kind of mixing will tend to nullify the separation normally attainable by the azeotropic distillation of mixtures of hydrocarbons of the same boiling point. Furthermore, if the prior distillation is made at a pressure below the normal distilling pressure, the separation of the paraffins from the naphthenes will be enhanced.[77]

Fig. 3 illustrates the results obtained in separating aromatics, naphthenes, and paraffins by azeotropic distillation, the separation being indicated by the change in refractive index with the amount of hydrocarbon recovered from the distillate. These distillations were performed as single-batch distillations in columns having a separating efficiency equivalent to about 100 theoretical plates.[77]

Part I of Fig. 3 shows the separation obtained in the azeotropic distillation, with methyl cyanide (boiling point 82°C.), of a mixture of toluene (boiling point 110.6°C.) with a substantially constant boiling (110.0 to 110.5°

TABLE 3

Hydrocarbons separated from a Mid-Continent petroleum by the A.P.I. Research Project 6 at the National Bureau of Standards, as of December 31, 1942

No.	Formula	Name	Type	B. P., °C.
1	CH_4	methane	paraffin	—161.6
2	C_2H_6	ethane	paraffin	— 88.9
3	C_3H_8	propane	paraffin	— 42.1
4	C_4H_{10}	isobutane	paraffin	— 11.7
5	C_4H_{10}	n-butane	paraffin	— 0.5
6	C_5H_{12}	2-methylbutane	paraffin	27.8
7	C_5H_{12}	n-pentane	paraffin	36.1
8	C_5H_{10}	cyclopentane	cycloparaffin	49.5
9	C_6H_{14}	2, 3-dimethylbutane	paraffin	58.0
10	C_6H_{14}	2-methylpentane	paraffin	60.3
11	C_6H_{14}	3-methylpentane	paraffin	63.3
12	C_6H_{14}	n-hexane	paraffin	68.7
13	C_6H_{12}	methylcyclopentane	cycloparaffin	71.9
14	C_7H_{16}	2, 2-dimethylpentane	paraffin	79.2
15	C_6H_6	benzene	aromatic	80.1
16	C_6H_{12}	cyclohexane	cycloparaffin	80.8
17	C_7H_{14}	1, 1-dimethylcyclopentane	cycloparaffin	87.5
18	C_7H_{16}	2-methylhexane	paraffin	90.0
19	C_7H_{14}	trans-1, 3-dimethylcyclopentane	cycloparaffin	90.9
20	C_7H_{14}	trans-1, 2-dimethylcyclopentane	cycloparaffin	91.9
21	C_7H_{16}	3-methylhexane	paraffin	92.0
22	C_7H_{16}	n-heptane	paraffin	98.4
23	C_7H_{14}	methylcyclohexane	cycloparaffin	100.9
24	C_7H_8	toluene	aromatic	110.6
25	C_8H_{18}	2-methylheptane	paraffin	117.6
26	C_8H_{16}	1, 1-dimethylcyclohexane*	cycloparaffin	119.8
27	C_8H_{16}	trans-1, 3-dimethylcyclohexane	cycloparaffin	120.3
28	C_8H_{16}	trans-1, 2-dimethylcyclohexane*	cycloparaffin	123.4
29	C_8H_{18}	n-octane	paraffin	125.6
30	C_8H_{16}	ethylcyclohexane	cycloparaffin	131.8
31	C_9H_{20}	2, 6-dimethylheptane	paraffin	135.2
32	C_8H_{10}	ethylbenzene	aromatic	136.2
33	C_9H_{18}	monocyclic†	cycloparaffin	136.7
34	C_8H_{10}	p-xylene	aromatic	138.4
35	C_8H_{10}	m-xylene	aromatic	139.2
36	C_9H_{20}	2, 3-dimethylheptane*	paraffin	140.7
37	C_9H_{18}	1, 2, 4-trimethylcyclohexane	cycloparaffin	141.2
38	C_9H_{20}	4-methyloctane	paraffin	142.4
39	C_9H_{20}	2-methyloctane	paraffin	143.3
40	C_9H_{20}	3-methyloctane	paraffin	144.2
41	C_8H_{10}	o-xylene	aromatic	144.4
42	C_9H_{18}	monocyclic†	cycloparaffin	145.6
43	C_9H_{16}	bicyclic†	cycloparaffin	146.7
44	C_9H_{20}	n-nonane	paraffin	150.7
45	C_9H_{12}	isopropylbenzene	aromatic	152.4
46	C_9H_{12}	n-propylbenzene	aromatic	159.5
47	C_9H_{12}	1-methyl—3-ethylbenzene	aromatic	161.6
48	C_9H_{12}	1-methyl—4-ethylbenzene	aromatic	162.5
49	C_9H_{12}	1, 3, 5-trimethylbenzene	aromatic	164.6
50	C_9H_{12}	1-methyl—2-ethylbenzene	aromatic	165.1
51	$C_{10}H_{22}$	4-methylnonane	paraffin	165.7
52	$C_{10}H_{22}$	2-methylnonane	paraffin	166.8
53	$C_{10}H_{22}$	3-methylnonane	paraffin	167.8
54	C_9H_{12}	1, 2, 4-trimethylbenzene	aromatic	169.2
55	$C_{10}H_{22}$	n-decane	paraffin	174.0
56	C_9H_{12}	1, 2, 3-trimethylbenzene	aromatic	176.1
57	$C_{11}H_{16}$	n-amylbenzene*	aromatic	204.1
58	$C_{10}H_{14}$	1, 2, 3, 4-tetramethylbenzene	aromatic	205.0
59	$C_{11}H_{16}$	1, 4-dimethyl-2-propylbenzene*	aromatic	206.6
60	$C_{10}H_{12}$	5, 6, 7, 8-tetrahydronaphthalene	aromatic-cycloparaffin	207.6
61	$C_{11}H_{16}$	1, 5-dimethyl-2-propylbenzene*	aromatic	208.5
62	$C_{11}H_{16}$	1, 3, 5-trimethyl-2-propylbenzene*	aromatic	212.3
63	$C_{12}H_{26}$	n-dodecane	paraffin	216.3
64	$C_{10}H_8$	naphthalene	aromatic	218.0
65	$C_{12}H_{16}$	phenylcyclopentane*	aromatic-cycloparaffin	220.7
66	$C_{11}H_{14}$	2-methyl—5, 6, 7, 8-tetrahydronaphthalene	aromatic-cycloparaffin	229.0
67	$C_{11}H_{14}$	1-methyl—5, 6, 7, 8-tetrahydronaphthalene	aromatic-cycloparaffin	234.4
68	$C_{11}H_{10}$	2-methylnaphthalene	aromatic	241.1
69	$C_{11}H_{10}$	1-methylnaphthalene	aromatic	244.8

*Identity not definitely established.
†Identity not yet determined.

TABLE 4

Distribution by boiling range and type of the hydrocarbons separated from a Mid-Continent petroleum by the A.P.I. Research Project 6 at the National Bureau of Standards

Type	Range			Total
	Gas	Gasoline	Kerosine	
Normal paraffin	4	6	1	11
Isoparaffin	1	16		17
Monocyclic cycloparaffin		14		14
Bicyclic cycloparaffin		1		1
Monocyclic aromatic		14		19
Bicyclic aromatic			3	3
Bicyclic aromatic-cycloparaffin			4	4
Total	5	51	13	69

C.) fraction of petroleum containing paraffin hydrocarbons with some naphthenes. The separation of toluene from these paraffin and naphthene hydrocarbons having substantially the same boiling point is almost quantitative.

Part II of Fig. 3 shows the separation obtained in the azeotropic distillation, with ethylene glycol monobutyl ether (boiling point 171°C.), of a narrow-boiling (166 to 169°C.) fraction of petroleum containing aromatic, naphthene, and paraffin hydrocarbons. This shows the almost complete separation of the aromatic hydrocarbons from the naphthenes and paraffins, and also a partial separation of the paraffins from the naphthenes.

Extraction

The process of extraction may be used to separate a mixture of hydrocarbons that have significantly different solubilities in a given solvent at a given temperature. The distribution ratio of the hydrocarbons between the solvent phase and the hydrocarbon phase may be altered by changing the solvent or the temperature or both. For the best results, an apparatus having a separating efficiency equivalent to many theoretical stages, and operated with reflux, is used. Solvents that have been used extensively in this work include liquid sulphur dioxide, acetone, methyl cyanide, and methyl formate.

Fig. 4 shows a laboratory apparatus 46 ft. high that is used with a solvent lighter than the hydrocarbons to be separated.[48] In operation, the solvent in B is distilled into the left side of the apparatus, condenses in J, and when a given head of liquid is reached, the solvent begins to pass from I through F and the hydrocarbon phase E. As it passes through the hydrocarbon phase, the solvent dissolves the more soluble components of the mixture of hydrocarbons, and the solvent phase then ascends to the boiler B. As the solvent is removed here, the solvent phase becomes saturated with hydrocarbons and from there on the less soluble hydrocarbons precipitate from this solution in the form of fine globules that fall through the ascending solvent phase. Fig. 5 gives an enlarged section of this column, showing the fine globules of hydrocarbon phase descending through the ascending solvent phase. After a time, the solution in the boiler B will contain the most soluble part of the original mixture of hydrocarbons, and fractions are withdrawn here at appropriate intervals. The solution withdrawn is replaced with fresh solvent.

When the solvent is heavier than the hydrocarbons to be separated, in which case the hydrocarbon globules must travel upward instead of downward, the reflux may be produced by refrigerating the bottom of the left arm so that the precipitated hydrocarbon phase ascends in fine globules and the hydrocarbons that are retained in solution pass across into the right arm of the apparatus to be removed as product at an appropriate time.[58] Three 55-ft. columns of this latter type are being used at the present time on aromatic-

Fig. 5. (Below) Enlarged section of the reflux arm of the extraction apparatus given in Fig. 4 showing the globules of the hydrocarbon phase. The scale at the left is in mm.

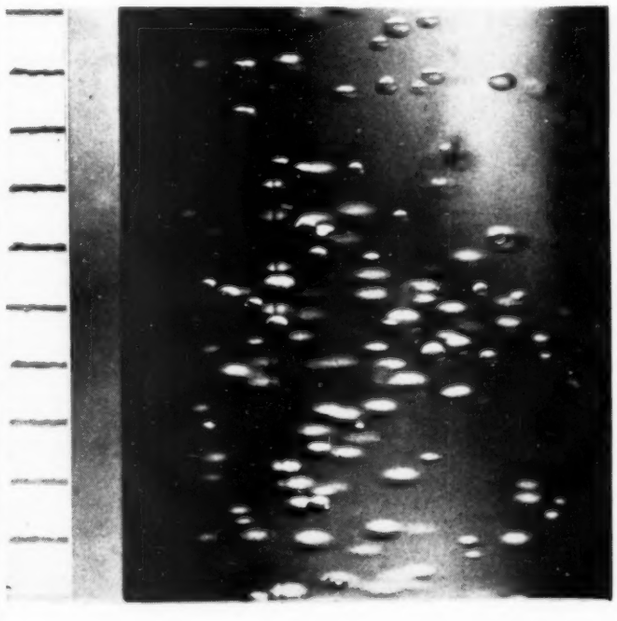
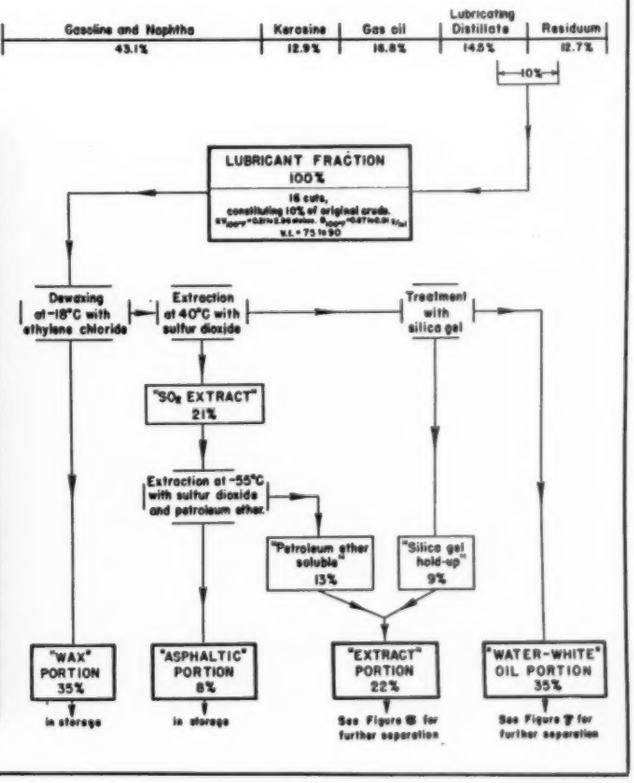


Fig. 6. (Right) Chart showing the separation of the lubricant fraction into four broad portions



free material of the kerosine fraction to separate paraffins from naphthenes (more soluble) by selective extraction with reflux, with methyl formate as the solvent at a temperature near 10°C.

Unlike the process of azeotropic distillation, the process of extraction will, within certain limits, operate successfully on a relatively wide-boiling mixture of different types of hydrocarbons.

Adsorption

The process of adsorption is used to separate aromatic hydrocarbons from paraffins and naphthenes for hydrocarbons of both low and high molecular weight.[40, 70] The mixture of hydrocarbons is filtered through a column of appropriate solid adsorbent, which preferentially adsorbs the aromatic hydrocarbons. In the work of the A.P.I. Research Project 6, silica gel has been found to be a satisfactory adsorbent. When a sufficient quantity of silica gel is used (about 15 to 20 g. of silica gel per gram of aromatic hydrocarbon), the aromatic hydrocarbons are retained quantitatively in the column. The process of adsorption operates successfully on extremely wide-boiling mixtures.

Crystallization

The process of crystallization is generally used to increase the purity of a hydrocarbon that has been concentrated by means of one or more of the other fractionating processes. The most frequently used procedure is to mix the hydrocarbon with the proper amount of a suitable solvent, take the mixture (usually with refrigeration) to a temperature that produces a "mush" or "slurry" of liquid with crystals of the wanted hydrocarbon, and then at this temperature to centrifuge the liquid from the crystals. In some cases, especially when it is sufficiently fluid near its melting point, the liquid hydrocarbon may be processed without solvent, and the crystals are freed from the mother liquor by centrifuging as before.

Determination of Properties

After a given hydrocarbon has been separated from petroleum in the manner described, a number of physical properties are measured for record and identification. These properties include the boiling point, freezing point, density, refractive index, and refractive dispersion. When the identity of the compound is not known, determinations of the molecular weight and the carbon-hydrogen content are also made. Other properties that are sometimes determined include the critical solution temperature in aniline, the viscosity, and the infra-red absorption spectrum.

Determination of Purity

Any rational method of purification will leave in a hydrocarbon only those impurities that have properties close to those of the given hydrocarbon, and such impurities tend to form an ideal solution with it. Furthermore, such impurities seldom form solid solutions with the given hydrocarbon. The ideal solution laws may, therefore, be applied to freezing and melting observations on such systems to ascertain quantitatively the amount of the unknown impurity. No property other than the freezing point can be so interpreted into concentration of impurity when the impurity is unknown.

The amount of impurity in the purest lot of the hydrocarbon is determined by means of time-temperature freezing and melting curves. With appropriate apparatus, and a thermometric system having a sensitivity of 0.001°C. per mm. on the scale, this procedure can be used to determine the amount of impurity within about 10 percent of itself and with a sensitivity of 0.0001 in mole fraction.[76] A large number of hydrocarbons isolated from petroleum in this work have contained 0.01 or less

Fig. 7. Chart showing the exhaustive separation of the "water-white" oil portion of the lubricant fraction.

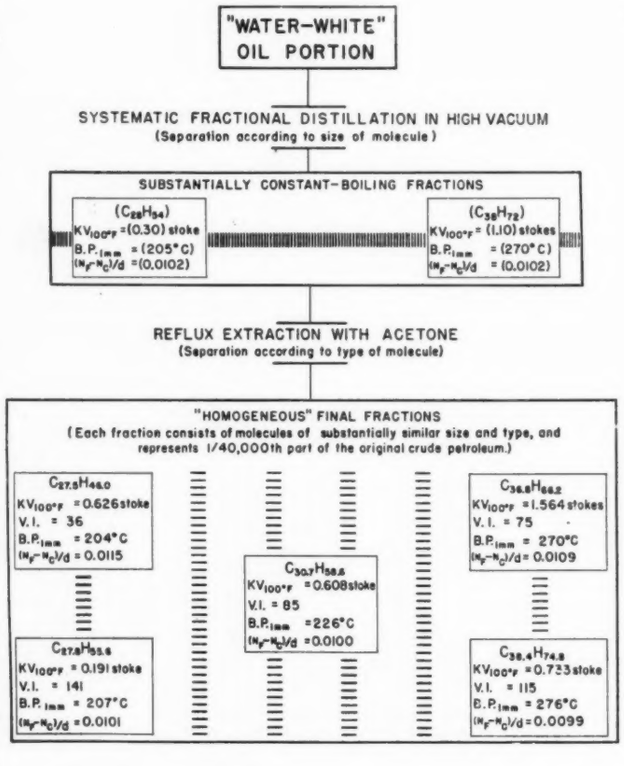
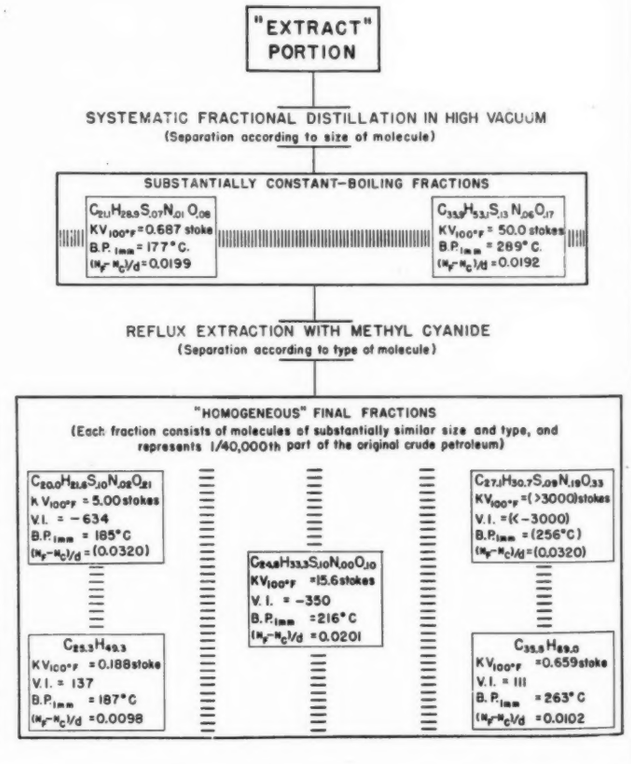


Fig. 8. Chart showing the exhaustive separation of the "extract" portion of the lubricant fraction



mole fraction of impurity, and some 0.001 or less mole fraction.

Hydrocarbons in Gas, Gasoline, and Kerosine Fractions

In Table 3 are listed the 69 hydrocarbons that have, to December 31, 1942, been separated from a Mid-Continent petroleum by the A. P. I. Research Project 6. According to type and boiling range, these hydrocarbons are distributed as shown in Table 4.

In connection with the hydrocarbons of the Mid-Continent petroleum listed in Table 3, the following points are of interest:

(a) The order of increasing difficulty of separating compounds of the various types is as follows: Normal paraffins; aromatics; *iso*paraffins and naphthenes (cycloparaffins);

(b) In the gasoline fraction, the amounts of the normal paraffins, *iso*-paraffins, naphthenes (cycloparaffins), and aromatics are roughly of the order 3,3,3, and 1, respectively.

(c) All normal paraffin hydrocarbons are present;

(d) All possible aromatic hydrocarbons, C_6 to C_9, of which there are 14, have been separated.

(e) Of the *iso*paraffins, the most abundant are the 2-methyl isomers.

(f) Of the naphthene (cycloparaffin) hydrocarbons, the amount of the alkylcyclopentanes is not greatly different from the amount of the alkylcyclohexanes.

Separation of the Lubricant Fraction

Because of the greater complexity of the lubricant fraction, and of the lack of sufficient quantity of material, the resolution of the lubricant fraction of the Mid-Continent petroleum under investigation was carried to the stage of "homogeneous" fractions, each containing molecules of the same size and type.**

Fig. 6 illustrates the scheme of separating the lubricant fraction into four broad portions having quite different properties. The material was dewaxed at minus 18°C. with ethylene chloride to produce a "wax" portion containing, in addition to the true wax, a considerable portion of clear oil. The remaining material was then subjected to extraction at about 40° C. with liquid sulphur dioxide to produce a "sulphur-dioxide extract." The material insoluble in the sulphur dioxide was treated by adsorption with silica gel to produce a "water-white" oil and a portion representing the "silica-gel hold-up". The "sulphur-dioxide extract" was brought into solution in liquid sulphur dioxide at minus 55°C., and extracted with petroleum ether at the same temperature to produce a "petroleum-ether-soluble" portion and an "asphaltic" portion, the latter from the material remaining in the sulphur dioxide layer. The "petroleum - ether - soluble" material was combined with the "silica-gel hold-up" to make what may be called the "extract" portion of the lubricant fraction. In this manner, the original lubricant fraction was separated into the following four broad fractions: "Wax" portion, 35 percent; "asphaltic" portion, 8 percent; "extract" portion, 22 percent; "water-white" oil portion, 35 percent.

The so-called "wax" portion (which contains a considerable amount of clear oil in addition to the true wax) and the "asphaltic" portion (the greater part of which was solid at room temperature, and which contains all the black tar-like constituents) were placed in storage, and were not further separated. The "extract" portion and the "water-white" oil portion were each subjected to an exhaustive separation with respect both to size and type of molecules.

Fig. 7 illustrates the manner in which the "water-white" oil portion was fractionated exhaustively by distillation and extraction. This oil was first subjected to a systematic distillation in high vacuum, through about eight stages, to produce a large number of substantially constant-boiling fractions. An indication of the properties of these fractions, which are mixtures of different types of molecules, is given in the two blocks, one at the low-boiling and one at the high-boiling end. These substantially constant - boiling fractions were then subjected to extraction with reflux in 46-ft. columns, with acetone (plus some water for the more soluble fractions) as the solvent, to produce the final fractions shown in the lower part of the figure. The nature of these final fractions is indicated by the properties given in the blocks for the most soluble and the least soluble fractions of both the low-boiling and the high-boiling ends, together with one fraction in the center of the "spread" formation.

Fig. 8 illustrates the exhaustive separation of the "extract" portion, by distillation and extraction. This material was processed in the same manner as was the "water-white" oil, except that the extraction occurred in 55-ft. columns with methyl cyanide (plus some acetone for the less soluble fractions) as the solvent. The nature of the final fractions is indicated by the properties in the blocks.

The quantity of each of the final "homogeneous" fractions of both the "water-white" oil and "extract" portions was about 15 grams, representing

**See references to publication numbe - 43, 45, 48, 49, 51, 63, 64, 65, and 66, at end of this article.

Fig. 9. Chart showing the content of sulphur, nitrogen, and oxygen in one series of final homogeneous fractions of the "extract" portion of the lubricant fraction. The scale of ordinates gives the percentage by weight of sulphur, nitrogen, and oxygen. The scale of abscissas gives the percentage extracted of the substantially constant-boiling fraction (see center column of the lower part of Fig. 8)

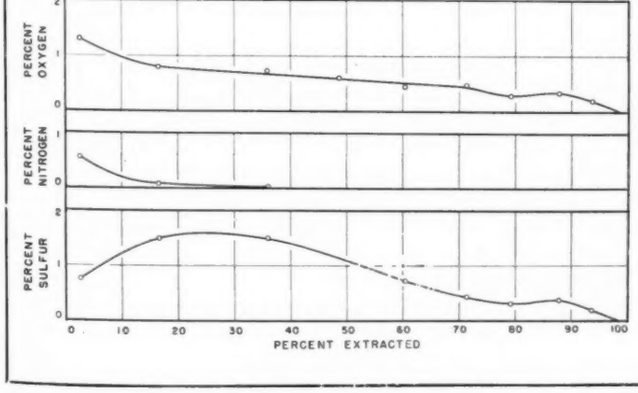


Fig. 10. Chart showing the number of rings per molecule for one series of homogeneous fractions of the "water-white" oil portion of the lubricant fraction. The scale of ordinates gives, per molecule, the total number of rings, the number of naphthene or cycloparaffin rings, and the number of aromatic rings. The scale of abscissas gives the percentage extracted of the substantially constant boiling fraction

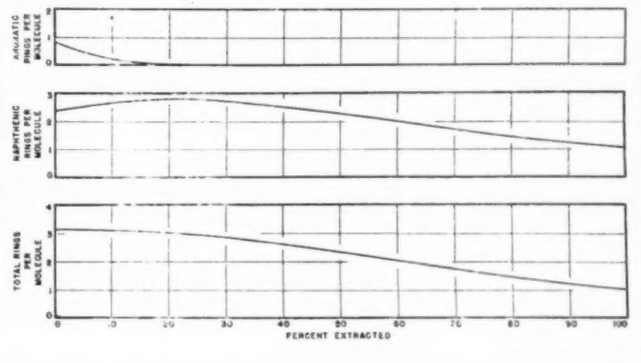


TABLE 5

Approximate average analysis of the middle part of the lubricant fraction with respect to kinds of molecules

(These molecules contain from 25 to 35 carbon atoms)

Portion	Percentage of lubricant fraction	Molecules composed of the following component parts, with the rings condensed (that is, joined through two carbon atoms) when more than one:	Percentage of the given portion‡	Percentage of lubricant fraction‡
"Water-white" oil	35	1 naphthene* ring + paraffin groups 2 naphthene rings + paraffin groups 3 naphthene rings + paraffin groups	92 (15) (45) (32)	32.2 (5.3) (15.7) (11.2)
		1 naphthene ring + 1 aromatic ring + paraffin groups	8	2.8
"Extract"†	22	2 naphthene rings + paraffin groups 3 naphthene rings + paraffin groups	8	1.8
		2 naphthene rings + 1 aromatic ring + paraffin groups 3 naphthene rings + 1 aromatic ring + paraffin groups	25	5.5
		2 naphthene rings + 2 aromatic rings + paraffin groups 1 naphthene ring + 3 aromatic rings + paraffin groups	67 (37) (30)	14.7 (8.1) (6.6)
"Wax"	35	Normal paraffins (plus possibly some isoparaffins) 1, 2 or 3 naphthene rings + paraffin groups	50 to 75 50 to 25	18 to 26 17 to 9
"Asphaltic"	8	Probably highly condensed multi-ring aromatics, very low in hydrogen, together with the bulk of the non-hydrocarbon material		

*Cycloparaffin.
†Contains some non-hydrocarbon material.
‡The values in parenthesis are less reliable than the others

1/40,000th part of the original crude petroleum from which it came, and consisted of compounds of substantially similar sizes and types. These fractions, although far from being pure compounds, appear to be nearer to pure compounds than any material (except normal paraffin hydrocarbons) hitherto separated from the lubricant fraction of any crude petroleum.

Both the "wax" and "water-white" oil portions of this lubricant fraction were substantially pure hydrocarbon material. The "extract" portion contained some sulphur, nitrogen, and oxygen compounds, but the bulk of the non-hydrocarbon material remained in the "asphaltic" portion. Analyses of the "extract" portion showed that the fractions of the distillate (see row in the upper part of Fig. 9) contained on the average, about 0.9 percent sulphur, 0.1 percent nitrogen, and 0.5 percent oxygen. The final process of extraction distributed this non-hydrocarbon material among the various final homogeneous fractions as shown in the blocks in the lower part of Fig. 9 and as illustrated in Fig. 9.

Types of Hydrocarbons in the Lubricant Fraction

The following properties were determined for all the important final fractions from both the "water-white" oil and "extract" portions: molecular weight; content of carbon and hydrogen; content of sulphur, nitrogen, and oxygen; boiling point at a pressure of 1 mm. Hg.; density; refractive index, N_D; refractive dispersion, N_F-N_C; kinematic viscosity at 100 and 210° F.; and aniline point. The aromatic content of selected fractions of the "extract" portion was determined by hydrogenation. The foregoing properties were also determined for the hydrogenated material.

These data on the properties of the fractions of the "water-white" oil and "extract" portions were compared with those of known hydrocarbons of high molecular weight in order to deduce the kinds of molecules constituting the various fractions. From these correlations, the information displayed in Figs. 10 and 11 and in Table 5 was obtained.

From the data obtained, the following average analysis was deduced with regard to the kinds of hydrocarbons in the middle portion of the original lubricant fraction of this Mid-Continent petroleum:

(a) Normal paraffins (plus possibly a small amount of *iso*paraffins), 18 to 26 percent;†

(b) naphthenes or cycloparaffins, with one, two, or three cycloparaffin rings and paraffin side chains, 51 to 43 percent;†

(c) mixed cycloparaffin-aromatic hydrocarbons with one aromatic ring and, in the same molecule, one, two, or three cycloparaffin rings, 8.3 percent;

(d) mixed cycloparaffin-aromatic hydrocarbons with two aromatic rings (condensed as in naphthalene) and, in the same molecule, two cycloparaffin rings, 8.1 percent;

(e) mixed cycloparaffin-aromatic hydrocarbons with three aromatic rings (condensed) and, in the same molecule, one cycloparaffin ring, 6.6 percent;

(f) "asphaltic" constituents, 8 percent.

The striking part of this analysis is the absence of any significant amount of purely *iso*paraffin hydrocarbons and, except in the "asphaltic" portion, of any purely aromatic hydrocarbons.

Publications of A.P.I. Research Project 6

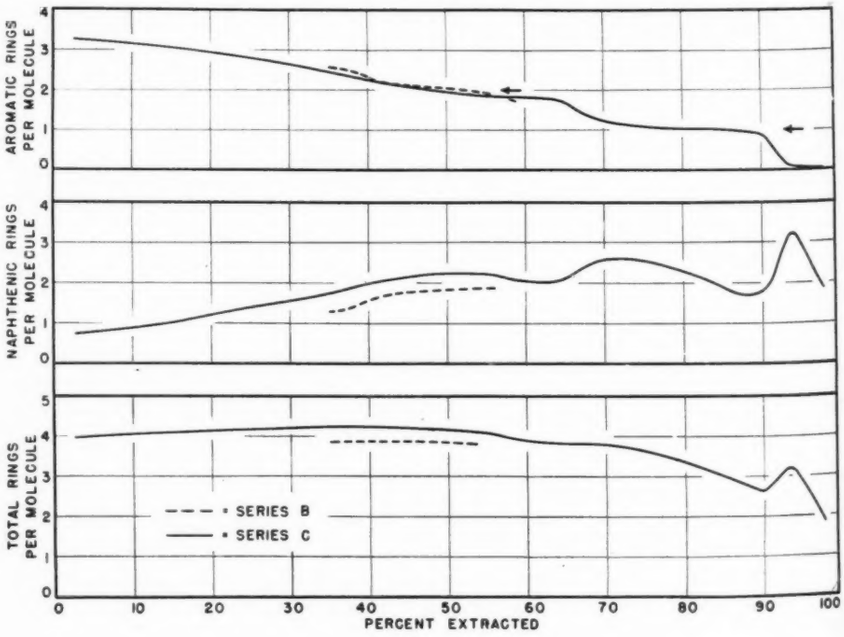
The following is a list of publications of the A.P.I. Research Project 6, numbered chronologically:‡

1. "Apparatus and Methods for the Separation, Identification, and Determination of

†The uncertainty in the amounts given here arises from lack of knowledge of the amount of true wax in the so-called "wax" portion.

‡Those papers published in the Journal of Research of the National Bureau of Standards, and for which a price is given, may be purchased separately from the U. S. Government Printing Office, Washington, D. C.

Fig. 11. Chart showing the number of rings per molecule for one series (and part of another) of homogeneous fractions of the "extract" portion of the lubricant fraction. The scale of ordinates gives, per molecule, the total number of rings, the number of naphthene or cycloparaffin rings, and the number of aromatic rings. The scale of abscissas gives the percentage extracted of the substantially constant boiling fraction



the Chemical Constituents of Petroleum," by E. W. Washburn, J. H. Bruun, and M. M. Hicks. *J. Research Natl. Bur. Standards, 2,* 467-88 (1929); (NBS Research Paper 45).

2. "Laboratory Rectifying Columns with Non-Siphoning Bubbling-cap Plates," by J. H. Bruun, *Ind. Eng. Chem.*, Anal. Ed., 1, 212-3 (1929).

3. "Convenient Reflux Regulator for Laboratory Stills," by J. H. Bruun. *Ind. Eng. Chem.*, Anal. Ed., 2, 187-8 (1930).

4. "The Principles of Measurement and Calculation in Their Application to the Determination of Diophantine Quantities," by E. W. Washburn, *J. Research Natl. Bur. Standards, 4,* 221-46 (1930); (NBS Research Paper 145, 10 cents).

5. "The Problem of Establishing the Identity and Purity of a Hydrocarbon Obtained from Petroleum," by E. W. Washburn. *Ind. Eng. Chem., 22,* 985-8 (1930).

6. "An Improved Victor-Meyer Molecular-Weight Apparatus," by M. M. Hicks-Bruun. *J. Research Natl. Bur. Standards,* 5, 575-83 (1930); (NBS Research Paper 215, 5 cents).

7. "On the Determination of the Empirical Formula of a Hydrocarbon," by E. W. Washburn. *J. Research Natl. Bur. Standards,* 5, 867-90 (1930); NBS Research Paper 236, 5 cents).

8. "Isolation of the Isomers of Hexane from Petroleum," by J. H. Bruun and M. M. Hicks-Bruun. *J. Research Natl. Bur. Standards,* 5, 933-42 (1930), (NBS Research Paper 239, 10 cents).

9. "Determination of the Toluene Content of a Mid-Continent Petroleum," by J. H. Bruun, R. T. Leslie, and S. T. Schicktanz. *J. Research Natl. Bur. Standards,* 6, 363-7 (1931); (NBS Research Paper 280, 5 cents).

10. "Separation of *n*-Octane from Petroleum by Distillation and Crystallization," by R. T. Leslie and S. T. Schicktanz. *J. Research Natl. Bur. Standards,* 6, 377-86 (1931); (NBS Research Paper 282, 10 cents).

11. "Determination of the Benzene and the Normal Hexane Content of a Mid-Continent Petroleum," by J. H. Bruun and M. M. Hicks-Bruun. *J. Research Natl. Bur. Standards,* 6, 869-79 (1931); (NBS Research Paper 311, 5 cents).

12. "Isolation and Determination of Cyclohexane in a Mid-Continent Petroleum," by J. H. Bruun and M. M. Hicks-Bruun. *J. Research Natl. Bur. Standards,* 7, 607-15 (1931); (NBS Research Paper 360, 5 cents).

13. "Isolation and Determination of Methylcyclopentane in a Mid-Continent Petroleum," by M. M. Hicks-Bruun and J. H. Bruun. *J. Research Natl. Bur. Standards,* 7, 799-809 (1931); (NBS Research Paper 375, 5 cents).

14. "Laboratory Rectifying Stills of Glass," by by J. H. Bruun and S. T. Schicktanz. *J. Research Natl. Bur. Standards,* 7, 851-82 (1931); (NBS Research Paper 379, 20 cents).

15. "Isolation of *n*-Nonane from a Mid-Continent Petroleum," by Joseph D. White and F. W. Rose, Jr. *J. Research Natl. Bur. Standards,* 7, 907-11 (1931); (NBS Research Paper 383, 5 cents).

16. "What Is Petroleum? Methods for the Isolation and Determination of the Chemical Constituents of Petroleum," by J. H. Bruun. *J. Chem. Education,* 8, 1930-44 (1931).

17. "Isolation and Determination of Normal Heptane and of Methylcyclohexane in a Mid-Continent Petroleum. Including a Determination of the Phase-Equilibrium Diagram for the Condensed System Normal Heptane-Methylcyclohexane," by M. M. Hicks-Bruun and J. H. Bruun. *J. Research Natl. Bur. Standards, 8,* 525-40 (1932); (NBS Research Paper 432, 5 cents).

18. "Isolation of *n*-Decane from Petroleum by Distillation and Equilibrium Melting," by J. H. Bruun and M. M. Hicks-Bruun. *J. Research Natl. Bur. Standards,* 8, 583-9 (1932); (NBS Research Paper 438, 5 cents).

19. "A Laboratory Apparatus for the Continuous Extraction of Liquids by Low-Boiling Solvents," by R. T. Leslie. *J. Research Natl. Bur. Standards, 8,* 591-9 (1932); (NBS Research Paper 439, 5 cents).

20. "Note on the Probable Presence of 2, 2-Dimethylpentane in a Mid-Continent Petroleum," by J. H. Bruun and M. M. Hicks-Bruun. *J. Research Natl. Bur. Standards, 9,* 53-9 (1932); (NBS Research Paper 458, 5 cents).

21. "Note on the Freezing Point of *iso*octane (2, 2, 4-trimethylpentane)," by J. H. Bruun and M. M. Hicks-Bruun. *J. Research Natl. Bur. Standards,* 9, 269-70 (1932); (NBS Research Paper 469, 5 cents).

22. "The Synthesis, Purification, and Certain Physical Constants of the Normal Hydrocarbons From Pentane to Dodecane, of *n*-Amyl Bromide and *n*-Nonyl Bromide," by B. J. Mair. *J. Research Natl. Bur. Standards,* 9, 457-72 (1932); NBS Research Paper 482, 5 cents).

23. "Isolation of the Three Xylenes From an Oklahoma Petroleum," by Joseph D. White and F. W. Rose, Jr. *J. Research Natl. Bur. Standards,* 9, 711-9 (1932); (NBS Research Paper 501, 5 cents).

24. "A Multi-Range Potentiometer and its Application to the Measurement of Small Temperature Differences," by H. B. Brooks and A. W. Spinks. *J. Research Natl. Bur. Standards,* 9, 781-98 (1932); (NBS Research Paper 506, 5 cents).

25. "1, 1-Dimethylcyclopentane and 2-methylhexane in a Mid-Continent Petroleum," by J. H. Bruun and M. M. Hicks-Bruun. *J. Research Natl. Bur. Standards,* 10, 465-73 (1933); (NBS Research Paper 542, 5 cents).

26. "Purification of Hydrocarbons by Crystallization From Liquid Methane. Isolation of 2-Methylheptane From Petroleum," by R. T. Leslie. *J. Research Natl. Bur. Standards, 10,* 609-18 (1933); (NBS Research Paper 552, 5 cents).

27. "Isolation of Ethylbenzene from an Oklahoma Petroleum," by J. D. White and F. W. Rose, Jr. *J. Research Natl. Bur. Standards, 10,* 639-45 (1933); (NBS Research Paper 554, 5 cents).

28. "Spectral Differentiation of Petroleum Hydrocarbons," by U. Liddel and Charles Kasper. *J. Research Natl. Bur. Standards, 11,* 599-618 (1933); (NBS Research Paper 610, 15 cents).

29. "Fractionation of Petroleum Into its Constituent Hydrocarbons," by E. W. Washburn. *Ind. Eng. Chem. 25,* 891 (1933).

30. "Note on an Improved Chain-Packed Distilling Column," by S. T. Schicktanz. *J. Research Natl. Bur. Standards,* 11, 89-92 (1933); (NBS Research Paper 579, 5 cents).

31. "A Simple Calorimeter for Heats of Fusion. Data on the Fusion of Pseudocumene, Mesitylene (α and β), Hemimellitene, *o*- and *m*-xylene, and on Two Transitions of Hemimellitene," by Frederick D. Rossini. *J. Research Natl. Bur. Standards, 11,* 553-9 (1933); (NBS Research Paper 607, 5 cents).

32. "The Isolation of Mesitylene, Pseudocumene, and Hemimellitene from an Oklahoma Petroleum," by B. J. Mair and S. T. Schicktanz. *J. Research Natl. Bur. Standards, 11,* 665-80 (1933); (NBS Research Paper 614, 5 cents).

33. "Chemical Constituents of Petroleum. A.P.I. Research Project 6," by E. W. Washburn. *Proc. Am. Petroleum Inst., 14 (III),* 111-22 (1933).

34. "A Fractionating Column With Fritted Glass Plates," by S. T. Schicktanz. *J. Research Natl. Bur. Standards,* 12, 259-61 (1934); NBS Research Paper 651, 5 cents).

35. "The Critical Solution Temperatures of Some Hydrocarbons in Sulfur Dioxide," by R. T. Leslie. *J Research Natl. Bur. Standards, 13,* 589-97 (1934); (NBS Research Paper 728, 5 cents).

36. "The Isolation of a Nonanaphthene from an Oklahoma Petroleum," by J. D. White and F. W. Rose, Jr. *J. Research Natl. Bur. Standards, 13,* 799-810 (1934); (NBS Research Paper 745, 5 cents).

37. "An Accurate Ebullioscopic Method for the Determination of the Molecular Weights of Non-volatile Petroleum Fractions," by B. J. Mair. *J. Research Natl. Bur. Standards, 14,* 345-57 (1935); (NBS Research Paper 772, 5 cents).

38. "An Apparatus for Measuring the Boiling Points of Lubricating Oils and Other Compounds of High Molecular Weight at Reduced Pressures," by S. T. Schicktanz. *J. Research Natl. Bur. Standards,* 14, 685-92 (1935); (NBS Research Paper 796, 5 cents).

39. "Separation of a Dimethylcyclohexane Fraction From a Mid-Continent Petroleum," by R. T. Leslie. *J. Research Natl. Bur. Standards,* 15, 41-50 (1935); (NBS Research Paper 808, 5 cents).

40. "Separation of Petroleum Hydrocarbons with Silica Gel," by B. J. Mair and J. D. White. *J. Research Natl. Bur. Standards, 15,* 51-62 (1935); (NBS Research Paper 809, 5 cents).

41. "Isolation of Ethylcyclohexane From a Mid-Continent Petroleum," by F. W. Rose, Jr., and J. D. White. *J. Research Natl. Bur. Standards, 15,* 151-61 (1935); (NBS Research Paper 817, 5 cents).

42. "Present Status of the Isolation and Identification of the Volatile Hydrocarbons in a Mid-Continent Petroleum," by R. T. Leslie and J. D. White. *J. Research Natl. Bur. Standards, 15,* 211-25 (1935); (NBS Research Paper 824, 5 cents).

43. "Apparatus and Methods for Investigating the Chemical Constitution of Lubricating Oil and the Preliminary Fractionation of

(Continued on Page 60)

New Power Unit Broadens Scope of Climax Engineering Company

YOU KNOW CLIMAX as the manufacturer of Blue Streak Gas Engines for oil industry, factory and engineering contractors; as the company that built the first successful gasoline engine for heavy duty cranes; and constructed engines so well that after almost 30 years of operation some of the first ones made are still in service.

WHEREVER SELF-CONTAINED POWER UNITS ARE NEEDED you are likely to find a Climax. Throughout America, in foreign towns and cities, and in remote, far-flung corners of the earth, Climax engines are delivering dependable power with a variety of local fuels and unskilled native supervision.

The first Climax engines were designed for service on tractors. They were so successful for this work that standard units and accessories were made to drive oil field equipment, power shovels, cranes, hoists, locomotives, snow plows, and for stationary service-pumping, electric power generation, etc. Then came increased demands for larger engines and higher speed units to meet modern demands for faster operating machinery.

Perhaps as well known as Climax Gas Engines are Climax Generating Sets—the outcome of a long uninterrupted program of product development. Through the years, as these sets became known, they have served an ever widening market. Prior to the present war, the majority of Climax Generating Sets were installed for emergency or stand-by service. For this work the sets carried a general guarantee to start and be on full load—automatically—within fifteen (15) seconds from the instant of outside power failure.

A count of Climax installations for power service includes practically every type of commercial, industrial and federal project. Included in the list are generating sets for public, office and store buildings, banks, warehouses, packing and processing plants, factories, hospitals, churches, terminals for airways, railroads, bus stations, jails, sewage plants, radio stations, theatres, camps, armories, arsenals, etc.

The new Climax V-12 is the latest addition to the line of Blue Streak power units. Strong as the originals, plus the addition of every new and proved technical improvement, it is the answer to your war demands for a high speed unit to step up power output and reduce down time.

And these are not the V-12's only assets.

Because it is built to stand the punishment of heavy duty service in engineering construction, oil fields and industrial plants, V-12 is a sound investment for your postwar production. Get the full details today by writing to Dept. PE, Climax Engineering Company, Clinton, Iowa.

ANNOUNCING TO ENGINE BUYERS

Easy Starting...Smooth Running and Abundant Power

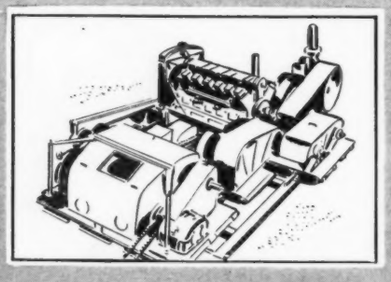
... are the three outstanding attributes of the new Climax V-12 Engine. These features make it an ideal power unit for deep well oil drilling, pumping, stationary power and construction applications. From the standpoint of design, construction and operation, this new engine has everything that technical ability and long experience can contribute.

The simple, well balanced design promotes high mechanical efficiency. The heavy reinforced construction gives the user many years of profitable and continuous service with negligible maintenance cost. Of particular value is the fact that the V-12 can be maintained by regular field or shop men *without the need for specialized training*.

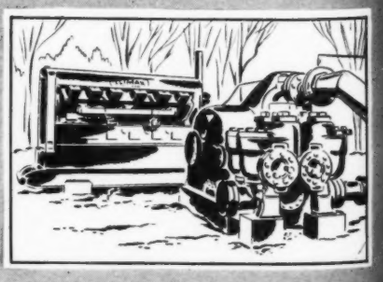
The V-12 also meets today's demands for a higher speed engine which will mesh with modern power consuming machinery. The normal speed range of this engine is from 600 r.p.m. to 1200 r.p.m. for either continuous or intermittent service.

Get all details now on how this new Climax unit can meet your individual needs. Complete information will be furnished by writing to Dept. PE, Climax Engineering Company, Clinton, Iowa.

V-12 IS A GENERAL PURPOSE PRIME MOVER WHICH DELIVERS PEAK



1—For deep oil well drilling



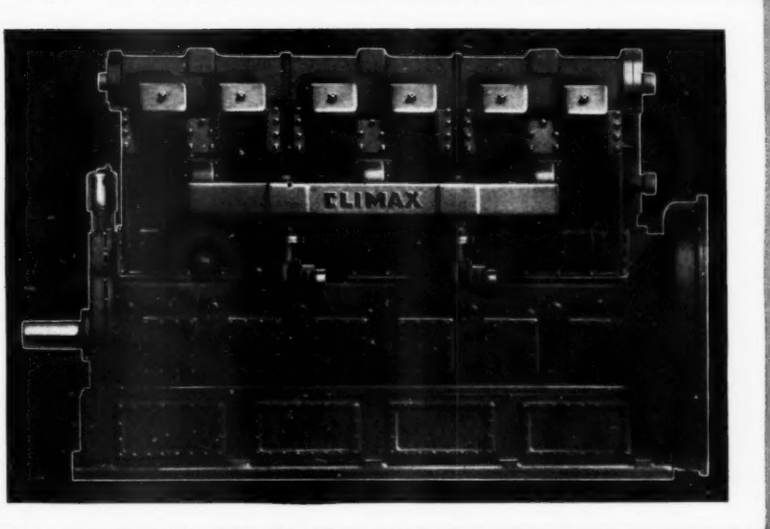
2—Driving pumps and compressors

...the NEW

Climax

Blue Streak V-12 ENGINE

for operation on gasoline, natural gas, butane, sewage gas and other fuels



FACTS

FOR THE MEN WHO MAKE DECISIONS

TYPE AND SIZE

A 12-cylinder "V" type engine available in two bores—Model V-335, 6½" bore and 7" stroke; Model V-390, 7" bore and 7" stroke.

ENGINE PERFORMANCE

Power Generating Capacity:
V-335 (6½" bore) develops 375 hp. at 1200 r.p.m.
V-390 (7" bore) develops 435 hp. at 1200 r.p.m.

FUEL RANGE AND REQUIREMENTS

Both models operate with equal facility on gasoline, natural gas, butane, sewage gas and other fuels. Fuel requirements are low, and the engines will deliver highest power output possible for the fuel used.

FEATURES OF DESIGN AND CONSTRUCTION

1—**COMPACTNESS AND ACCESSIBILITY**—The "V" type engine permits lightest weight with shorter overall length. Easier maintenance and servicing are made possible by the outside location of all accessories.

2—**HIGH MECHANICAL EFFICIENCY**—Balanced design, dual ignition and water-cooled manifolding result in peak mechanical efficiency for the new V-12.

3—**DUAL IGNITION**—V-12 can be furnished in the following combinations of dual ignition:

a — Dual battery ignition.
b — Dual magneto ignition.
c — Battery and magneto ignition.

Each cylinder has two spark plugs. These two plugs provide a greater flame; and shut down due to ignition failure is practically eliminated. Should one plug fail, the other will continue to operate without impairing the performance of the engine.

4—**WATER-COOLED MANIFOLD** is designed to attain uniform quality of gas mixtures. It is located between and above cylinder blocks with all turns and bends reduced to a minimum.

5—**CYLINDER BLOCKS CAST IN PAIRS** from close-grained cast iron designed with an ample factor of safety to take the stresses encountered under all operating conditions.

6—**AMPLE COOLING SURFACES**—Wide spaced, large capacity water jackets cover entire length of stroke. This results in equal expansion of cylinder bores.

7—**WET CYLINDER SLEEVES**—Promote long life, simplify maintenance and add to economy of operation.

8—**SEVEN BEARING CRANKSHAFT** is carried in precision type, steel back babbitt-lined bearings. These are rigidly supported by heavy ribbed and flanged housing members.

9—**ALUMINUM PISTONS** are of heavy ribbed construction fitted with five rings, and full floating piston pins. Sealed compression is attained by locating four rings above piston pins and one ring below.

10—**CONNECTING RODS** are rifle drilled from drop-forged, heat-treated steel. The large ends are machined to receive replaceable precision bushings.

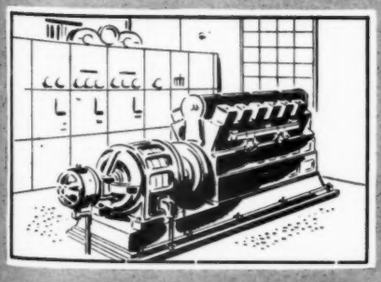
11—**OVERHEAD VALVES** with inserted valve seats and fully enclosed push rods promote high operating efficiency and protection against harmful atmospheric effects.

12—**DUAL CARBURETOR FLEXIBILITY**—Optimum performance under a wide variety of operating conditions is made possible by the dual carburetors on each bank of cylinders. In operation they compensate one another and give precise mixtures as required.

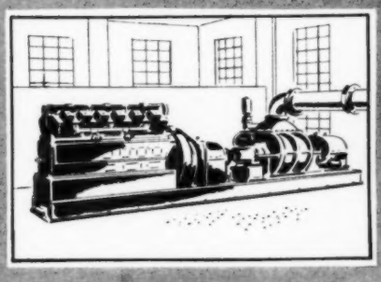
ACCESSORY EQUIPMENT FOR THE V-12 ENGINE

Where required, Climax furnishes a complete range of accessory equipment such as starting devices, air cleaners, filters, radiators, heat exchangers, etc. All of this may be selected to meet the specific needs of the engine application.

PERFORMANCE IN THE 375 h.p. AND 435 h.p. RANGE FOR THE FOLLOWING SERVICES:



3—Power for electric lighting and power plants



4—In sewage disposal plants

Climax Engineering Company

GENERAL OFFICES & FACTORY
CLINTON, IOWA

REGIONAL OFFICE DALLAS, TEXAS

(Continued from Page 57)

the Lubricating-Oil Fraction of a Mid-Continent Petroleum," by B. J. Mair, S. T. Schicktanz, and F. W. Rose, Jr. *J. Research Natl. Bur. Standards*, 15, 557-73 (1935); (NBS Research Paper 849, 5 cents).

44. "The Chemical Constitution of the Gasoline Fraction of Petroleum. A.P.I. Research Project 6," by Frederick D. Rossini. *Proc. Am. Petroleum Inst., 16M (III)*, 47-62 (1935); *Oil & Gas J.*, 33, No. 52, 61 (1935); *Refiner & Natural Gasoline Mfr.*, *14*, 255 (1935).

45. "Fundamental Research on the Chemical Constitution of Lubricating Oil. A.P.I. Research Project 6," by Frederick D. Rossini. *Proc. Am. Petroleum Inst., 16M (III)*, 63-77 (1935); *Oil & Gas J.*, 34, No. 6, 41 (1935); *Refiner & Natural Gasoline Mfr.*, *14*, 266 (1935).

46. "Composition of Petroleum Wax," by B. J. Mair and S. T. Schicktanz. *Ind. Eng. Chem.*, *28*, 1056-7 (1936).

47. "Hydrocarbons in the Fraction of a Mid-Continent Petroleum Distilling Between 115 and 124°C.," by R. T. Leslie. *J. Research Natl. Bur. Standards*, 17, 761-70 (1936); (NBS Research Paper 943, 10 cents).

48. "Extraction, with Acetone, of Substantially Constant-Boiling Fractions of a 'Water-White' Lubricating Oil," by B. J. Mair and S. T. Schicktanz. *Ind. Eng. Chem.*, *28*, 1446-51 (1936); *J. Research Natl. Bur. Standards*, *17*, 909-22 (1936); (NBS Research Paper 953, 10 cents).

49. "Relationships Between the Physical Properties and Chemical Constitution of Lubricating-Oil Fractions," by B. J. Mair and C. B. Willingham. *Ind. Eng. Chem.*, *28*, 1452-60 (1936); *J. Research Natl. Bur. Standards*, *17*, 923-42 (1936); (NBS Research Paper 954, 10 cents).

50. "Isolation of an *Iso*nonane From Petroleum. —Its Fractionation From Naphthenes by Distillation with Acetic Acid," by J. D. White and F. W. Rose, Jr. *J. Research Natl. Bur. Standards*, *17*, 943-54 (1936); (NBS Research Paper 955, 5 cents).

51. "The Chemical Constituents of Lubricating Oil.—A.P.I. Research Project 6," by Frederick D. Rossini. *Proc. Am. Petroleum Inst., 17, (III)*, 59-68 (1936); *Oil & Gas J., 35*, No. 26, 146 (1936); *Refiner & Natural Gasoline Mfr., 15*, 499 (1936).

52. "Separation of Constant-Boiling Mixtures of Naphthene and Paraffin Hydrocarbons by Distillation with Acetic Acid," by S. T. Schicktanz. *J. Research Natl. Bur. Standards*, *18*, 129-36 (1937); (NBS Research Paper 967, 5 cents).

53. "Study of the Crystal Behavior of Hydrocarbons," by R. T. Leslie and W. W. Heuer. *J. Research Natl. Bur. Standards*, *18*, 639-44 (1937); (NBS Research Paper 1000, 10 cents).

54. "Infrared Absorption of 19 Hydrocarbons, Including 10 of High Molecular Weight," by F. W. Rose, Jr. *J. Research Natl. Bur. Standards*, *19*, 143-61 (1937); (NBS Research Paper 1017, 5 cents).

55. "Separation of the Three Methyloctanes from Mid-Continent Petroleum," by J. D. White and A. R. Glasgow, Jr. *J. Research Natl. Bur. Standards*, *19*, 423-35 (1937); (NBS Research Paper 1033, 5 cents).

56. "Study of Ball Packings for Laboratory Rectifying Columns," by A. R. Glasgow, Jr., and S. T. Schicktanz. *J. Research Natl. Bur. Standards*, *19*, 593-603 (1937); (NBS Research Paper 1049, 5 cents).

57. "A Decade of Research on the Chemical Constitution of Petroleum," by Frederick D. Rossini. *Proc. Am. Petroleum Inst. 18 (III)*, 36-59 (1937); *Oil & Gas. J. 36*, No. 26, 193-222 (1937); *Refiner & Natural Gasoline Mfr. 16*, No. 11, 545-62 (1937).

58. "A Laboratory Extraction Apparatus and its Use in Separating a Lubricating-Oil Fraction with Acetic Acid," by S. T. Schicktanz. *J. Research Natl. Bur. Standards*, *20*, 83-6 (1938); (NBS Research Paper 1067, 5 cents).

59. "Quantitative Analysis, with Respect to the Component Structural Groups, of the Infrared (1 to 2 mu) Molal Absorptive Indices of 55 Hydrocarbons," by F. W. Rose, Jr. *J. Research Natl. Bur. Standards*, *20*, 129-57 (1938); (NBS Research Paper 1072, 10 cents).

60. "Separation of *Iso*propylbenzene From a Mid-Continent Petroleum by Adsorption with Silica Gel and Distillation with Acetic Acid," by J. D. White and F. W. Rose, Jr. *J. Research Natl. Bur. Standards*, *21*, 151-65 (1938); (NBS Research Paper 1122, 5 cents).

61. "Separation, by Distillation with Acetic Acid, of the Aromatic Hydrocarbons From the Fraction of a Mid-Continent Petroleum Boiling Between 154° and 162°C.," by F. W. Rose, Jr., and J. D. White. *J. Research Natl. Bur. Standards*, *21*, 167-84 (1938); (NBS Research Paper 1123, 5 cents).

62. "A Continuous High-Vacuum Still and Boiling-Point Apparatus, and the Systematic Distillation of a Dewaxed Lubricant Fraction of Petroleum," by R. T. Leslie and W. W. Heuer. *J. Research Natl. Bur. Standards*, *21*, 515-33 (1938); (NBS Research Paper 1142, 10 cents).

63. "Exhaustive Fractionation, by Distillation and Extraction, of the 'Extract' Portion of the Lubricant Fraction From a Mid-Continent Petroleum," by B. J. Mair and C. B. Willingham. *J. Research Natl. Bur. Standards*, *21*, 535-63 (1938); (NBS Research Paper 1143, 10 cents).

64. "Hydrogenation of the 'Extract' Portion of the Lubricant Fraction from a Mid-Continent Petroleum," by B. J. Mair, C. B. Willingham, and A. J. Streiff. *J. Research Natl. Bur. Standards*, *21*, 565-80 (1938); (NBS Research Paper 1144, 5 cents).

65. "Chemical Constitution of the 'Extract' Portion of the Lubricant Fraction From a Mid-Continent Petroleum," by B. J. Mair, C. B. Willingham, and A. J. Streiff. *J. Research Natl. Bur. Standards*, *21*, 581-607 (1938); (NBS Research Paper 1145, 10 cents).

66. "Hydrocarbons in the Lubricant Fraction of Petroleum," by Frederick D. Rossini. *Proc. Am. Petroleum Inst. 19 (III)*, 99-113 (1938); *Oil & Gas J. 37*, No. 27, 141-53 (1938); *Refiner & Natural Gasoline Mfr. 17*, No. 11, 557-67 (1938).

67. "Separation of 1, 2, 4-trimethylcyclohexane and an *Iso*nonane From a Mid-Continent Petroleum," by Joseph D. White and Augustus R. Glasgow, Jr. *J. Research Natl. Bur. Standards*, *22*, 137-52 (1939); (NBS Research Paper 1173, 10 cents).

68. "Summary of an Investigation of the Composition of a Mid-Continent Petroleum Distillate, Boiling Between 100° and and 130°C.," by Robert T. Leslie. *J. Research Natl. Bur. Standards*, *22*, 153-70 (1939); (NBS Research Paper 1174, 10 cents).

69. "2, 6-Dimethylheptane: Its Synthesis, Properties, and Comparison with an *Iso*nonane From Petroleum," by Joseph D. White, Frank W. Rose, Jr., George Calingaert, and Harold Soroos. *J. Research Natl. Bur. Standards*, *22*, 315-19 (1939); (NBS Research Paper 1184, 5 cents).

70. "Separation of Hydrocarbons of High Molecular Weight by Adsorption on Silica Gel," by Charles B. Willingham. *J. Research Natl. Bur. Standards*, *22*, 321-7 (1939); (NBS Research Paper 1185, 5 cents).

71. "Efficiency of a Rotary Distillation Column," by Beveridge J. Mair and Charles B. Willingham. *J. Research Natl. Bur. Standards*, *22*, 519-27 (1939); (NBS Research Paper 1201, 5 cents)

72. "Reflux Regulator and Head for Laboratory Rectifying Columns," by Frederick D. Rossini and Augustus R. Glasgow, Jr. *J. Research Natl. Bur. Standards*, *23*, 509-14 (1939); (NBS Research Paper 1249, 5 cents).

73. "Separation of the Aromatic Hydrocarbons, and the Isolation of *n*-Dodecane, Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene, from the Kerosine Fraction of Petroleum," by Beveridge J. Mair and Anton J. Streiff. *J. Research Natl. Bur. Standards*, *24*, 395-414 (1940); (NBS Research Paper 1289, 5 cents.)

74. "Isolation of 3-Methylhexane, Trans-1, 2-Dimethylcyclopentane, and Trans-1, 3-Dimethylcyclopentane from Petroleum," by Augustus R. Glasgow, Jr. *J. Research Natl. Bur. Standards*, *24*, 509-29 (1940); (NBS Research Paper 1126, 5 cents).

75. "Use of Azeotropic Distillation in Separating Hydrocarbons from Petroleum," by Frederick D. Rossini, Beveridge J. Mair, and Augustus R. Glasgow, Jr. *Proc. Am. Petroleum Institute, 21 (III)*, 43-7 (1940).

76. "Determination of Freezing Points and Amounts of Impurity in Hydrocarbons From Freezing and Melting Curves," by Beveridge J. Mair, Augustus R. Glasgow, Jr., and Frederick D. Rossini. *J. Research Natl. Bur. Standards*, *26*, 591-620 (1941); (NBS Research Paper 1397, 10 cents).

77. "Separation of Hydrocarbons by Azeotropic Distillation," by Beveridge J. Mair, Augustus R. Glasgow, Jr., and Frederick D. Rossini. *J. Research Natl. Bur. Standard, 27*, 39-63 (1941); (NBS Research Paper 1402. 10 cents).

78. "Isolation of 1, 2, 3, 4-Tetramethylbenzene, 5, 6, 7, 8-Tetrahydronaphthalene, 1-Methyl-5, 6, 7, 8-Tetrahydronaphthalene, and 2-Methyl-5, 6, 7, 8-Tetrahydronaphthalene From Petroleum," by Beveridge J. Mair and Anton J. Streiff. *J. Research Natl. Bur. Standards*, *27*, 343-59 (1941); (NBS Research Paper 1423, 10 cents).

79. "Progress Report on the Hydrocarbons in the Kerosine Fraction of Petroleum. A.P.I. Research Project 6," by Frederick D. Rossini and Beveridge J. Mair. *Proc. Am. Petroleum Inst. 22, (III)*, 6-12 (1941); *Oil & Gas. J. 40*, No. 26, 129-32 (1941); *Refiner & Natural Gasoline Mfr. 20*, No. 11, 494-98 (1941).

80. "Hydrocarbons in Petroleum," by Frederick D. Rossini. *Record of Chem. Progress*. September, 1942.

——— ☆ ☆ ☆ ———

P 420.11
P 367.

Recent Developments In Formation Logging

PETROLEUM ENGINEER Exclusive Feature

☆ Rate-of-penetration logs, caliper logs, temperature logs, and logging by inspection of drilling fluid

Part 1

by Lester C. Uren

Professor of Petroleum Engineering, University of California

THIS, the third and concluding article of a series reviewing recent progress in development of methods useful in formation logging, is concerned with the technique of making rate-of-penetration logs, well caliper logs, temperature logs, and logs made by inspection of drilling fluid returns, their interpretation and applications. Earlier articles of the series, printed in the two preceding issues of *The Petroleum Engineer*, were concerned with electrical logs, radioactivity logs, and geochemical logs.

Drilling-Time or Rate-of-Penetration Logs

For many years, drillers, engineers, contractors, and oil-company officials have been interested in drilling-time records, indicating the rate of penetration in drilling. Early records were, in many cases, a mere assemblage of figures showing the rate of progress in a stated depth interval. At times, these records were prepared in graphic form, correlated with a graphic strip log showing depths to top and bottom of the formations penetrated.[9] Thus, in Fig. 1, the graph at the right of the stratigraphic log indicates the progress made during each day of drilling, the slope of the inclined lines being a function of the rate of penetration. In gathering data for detailed rate-of-penetration records, the drill stem or "kelly" is marked at 1-ft. intervals and the driller notes the time when each foot mark reaches the level of the top of the table bushings. Time is deducted for intervals when, for any reason, the bit is "off-bottom".

Drilling-time recording instruments. Manually recorded drilling-time records require close attention on the part of the driller and to free him of this responsibility, several automatic and semi-automatic drilling-time recording instruments have been developed. A popular semi-automatic drilling-time recording instrument has been

LESTER C. UREN

developed by the Lane-Wells Co.[3] This is enclosed in a metal case and is mounted on a pedestal or post near the driller's position in the rig. Through a window in the front of the instrument case, appears a chart that is moved vertically through a uniform interval whenever the driller presses a trigger projecting from the under side of the case.[6] This he does each time one of a series of reference marks at 1-ft. intervals along the "kelly" reaches the level of the driving bushing of the rotary machine. Each time the trigger is pressed, a recording stylus or pen actuated by clock-work, moves quickly to the left margin of the chart and begins drawing a horizontal line across the chart. This line progresses to the right at a certain constant rate per minute of time, and the length of the line drawn between two successive applications of the trigger thus becomes a measure of the rate of penetration. Fig. 2 illustrates the type of record obtained with this instrument.

A short line indicates a rapid rate of drilling; a long line, a slow rate of progress. The instrument is not connected in any way with the drilling mechanism, and it places a minimum of responsibility on the driller, short of fully automatic recording. A graphic, easily interpreted record is produced on the chart of the instrument as drilling proceeds. No computations or translation of records on the drafting board are necessary.

The driving mechanism may be adjusted for varying rates of movement of the recording stylus or pen and of the interval between horizontal lines representing the depth scale. Horizontal drilling-time lines on 2 in. of the log depth, may be 100, 50, or 20 for each 100 ft. of hole, to correspond with timing intervals of 1-, 2-, or 5-ft., respectively. The rate of penetration may vary from as little as one or two to as much as a hundred or more feet per hour; hence, some adjustment of the instrument to alter the scale of the record is helpful, especially when detailed studies of particular intervals are to be made.

A fully automatic type of drilling-time recorder has been described by C. A. Yeatman.[10] This consists of a simple fluid-pressure system connecting a reservoir mounted on the swivel, through a flexible tube, with a recording pressure gauge below the derrick floor. A recording pen, responsive to the downward movement of the swivel on the upper end of the drill column, draws a continuous graph on a revolving circular chart. With this device, the record obtained at the well does not directly indicate the rate of penetration nor the drilling speed, but requires interpretation. This is done with the aid of a transparent circular template, which is superimposed over the record chart. Curved lines on the template, matched against the slope of the graph, indicate the rate of penetration at any time. Rates of penetration must then be plotted in profile form with respect to a depth scale. This fully automatic drilling-time recording instrument may

(Continued on Page 66)

DEPENDABLE SUB-SURFACE DATA

REED ROLLER BIT COMPANY

POST OFFICE BOX 2119

HOUSTON, TEXAS, U. S. A.

ON YOUR NEXT
Wilcox
REDUCE YOUR CORING COSTS
with
REED
CORE
DRILLS
A Complete Coring Service

(Continued from Page 63)

provide a continuous record of all that is done with the drilling equipment during each hour of the day and thus provide the administrative officials with a basis for checking the activity and efficiency of the drilling crews.[2]

Paul Nichols of the Indian Territory Illuminating Oil Co., has developed an automatic type of drilling-rate recorder that embodies a moving-strip type of chart, driven by clock-work, and a recording stylus responsive to downward movement of the drill column.[5] Connection between the drill column and the instrument is made by a flexible wire line, one end of which is attached to the goose-neck of the swivel, passing thence up through the derrick, over a sheave and down to the instrument, which may be placed on the derrick floor or in a near-by "dog-house". Within the instrument, the line passes around a sheave and then back to the derrick, where the free end passes over another sheave and suspends a weight that maintains uniform tension. Thus, the sheave in the instrument is slowly revolved as the drill column descends. Several cams attached to the rim of the instrument sheave, engage the mechanism that actuates the recording stylus, causing it to indicate depths in feet on the time graph. As drilling progresses, the chart moves at a uniform time rate and the stylus draws a smooth longitudinal line, notched at intervals to indicate the times at which each successive foot of depth is attained. A magnetic device causes the stylus to be displaced to one side of its normal position whenever the drill column is raised, and notes may be made on the chart opposite these time intervals, to indicate the character of operations under way. Interpretation of the record chart involves simple comparison of the intervals between 1-ft. depth marks along the vertical drilling-time line and horizontal lines ruled on the chart, representing time intervals.

Still another method of determining the rate of advance in drilling is that employed in the fluid-control system of continuous logging of drilling fluid, described in a later section. Here, by a knowledge of the volumetric capacity of the well per foot of depth, and a determination of the time necessary for fluid to travel from the bottom of the well to the surface, the depth of the well at a given time can be determined.[23] Successive determinations of this character indicate the rate of progress. In this same logging system, a companion instrument is used to indicate the depth of the well at any time. This is actuated by a pair of Selsyn motors, the primary motor being driven by mechanism that is responsive to the downward movement of the traveling block. An electrical instrument in the same circuit indicates the momentary rate of penetration of the bit and a recording pen draws a continuous drilling-rate profile on a strip-chart moving under the pen at a uniform time rate.

Factors Responsible for Variation in Rate of Penetration

The rate of progress in drilling depends upon several factors.[8] The lithologic character of the formation in which the drill is operating is a factor of primary importance, particularly its hardness: a property depending upon its mineral content, degree of cementation and character of cementing material, porosity, permeability, etc. Other important factors are the design of the bit, its mechanical condition and extent of wear, and the downward pressure maintained upon it by the drill column. The rate of progress in drilling also depends, particularly in soft formations, upon the character and rate of circulation of the drilling fluid and the velocity with which it is ejected from the apertures in the bit. Another significant factor is the rate of rotation of the drill. Perhaps most important of all, is the skill of the driller who, by manipulation of the drawworks brake, controls the rate of feeding of the drill as it penetrates the formation.

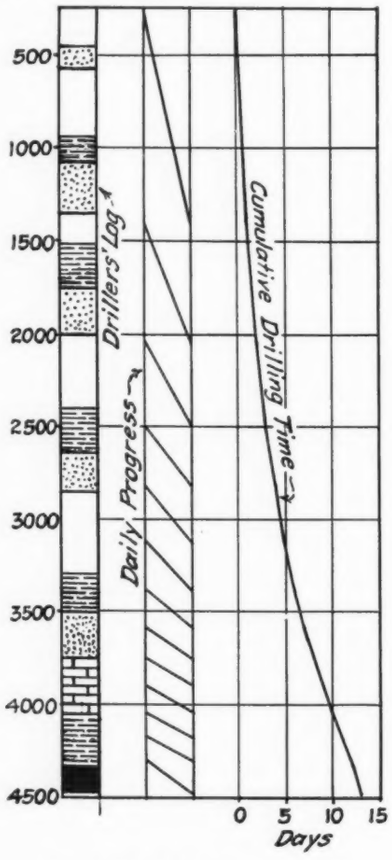


Fig. 1. Methods of graphically displaying drilling time

Utilization of Rate-of-Penetration Data

With so many factors influencing the rate of penetration of the drill, one would expect that it would be difficult to draw from a record of it any valid conclusions concerning changes in the character of the formation. Yet, it appears that most of these factors either tend to remain reasonably constant in their influence, or they are of so much less importance than the character of the formation that they do not prevent the rate-of-penetration data from being used as an index of formation resistance. The record is essentially one of comparative rather than absolute values. Certain it is, that in many cases surprisingly accurate logs, showing depths to top and bottom of reference strata, and character of the material comprising different formation intervals, are obtained by skilled interpretation of such records. Erratic control of bit pressure in manual regulation of the feeding mechanism may lead to conditions in which the rate of penetration fluctuates widely; but a process of averaging or integrating rates over longer time intervals will usually produce a significant result. Best results are obtained when bit pressure is automatically regulated.

A rate-of-penetration log often compares closely with the self-potential profile of the electrical log through the same interval. This is reasonable inasmuch as the rate of penetration doubtless bears some direct relation to the porosity and permeability of the formations drilled. Indeed, it is believed that in some areas, the drilling-time log might be a better index of the lithology of the strata penetrated by the drill than the electrical log. It has the advantage over the electrical log that it is assembled while the well is drilling, whereas the electrical log is usually made after the drilling of an interval is completed. In any case, the drilling-time record will be of material help in interpreting the electrical log.

Often drilling-time records will be of value in indicating likely reservoir rocks in formations penetrated by the drill. Thus, they have been of assistance in locating the more permeable and porous intervals in limestone reservoir rocks in central Kansas.[4] Excellent correlations of formations between nearby wells are frequently possible by comparison of drilling-time records. Such records are also of value in any study of drilling bit performance or of the comparative advantages of different bit

THE TERMS Color, Standard and Ensign are born of certain well-defined usages of long standing. The term flag applies generally, regardless of size, relative proportions or manner of display. The Color is a flag carried by dismounted units, for supreme commanders and general officers, so authorized; Standard is a flag carried by mounted or motorized units; Ensign is a flag flown on airships, ships, tenders, launches and small boats.

Supreme commanders and General officers of the United States Army are authorized to display both Color and Standard of a design approved by the Secretary of War. Regiments have similarly approved Color or Standard, depending upon their branch of service.

Colors for the General of the Armies and Chief of Staff, have been in use many years, while those for the Commanding Generals of the Army Ground Forces, Army Air Forces and Services of Supply have been just recently created.

In the center of all regimental Colors and Standards is the American Eagle, with an olive branch in his *dexter talon and 13 arrows in his **sinister. On the scroll in the eagle's beak is the regimental motto; in the scroll below the eagle is the official designation of the regiment.

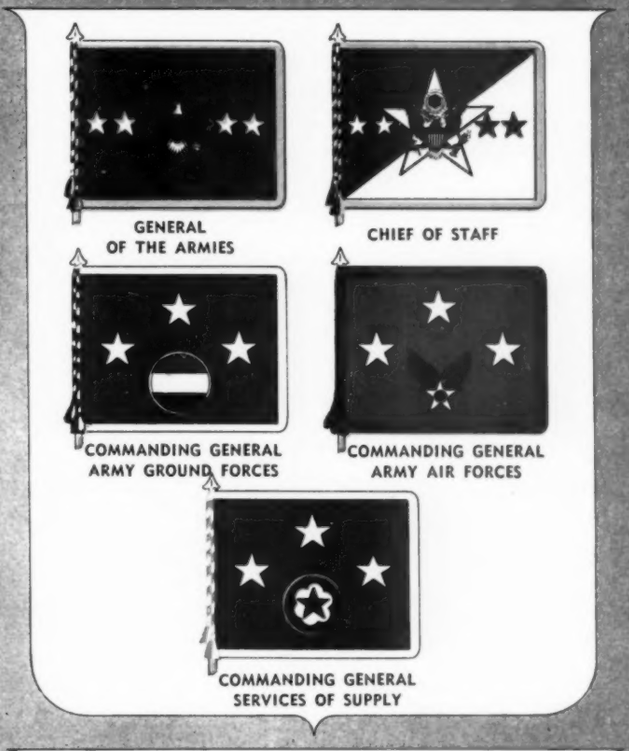
Regiments having an approved coat of arms place the shield thereof on the eagle's breast, with the regimental crest above his head.

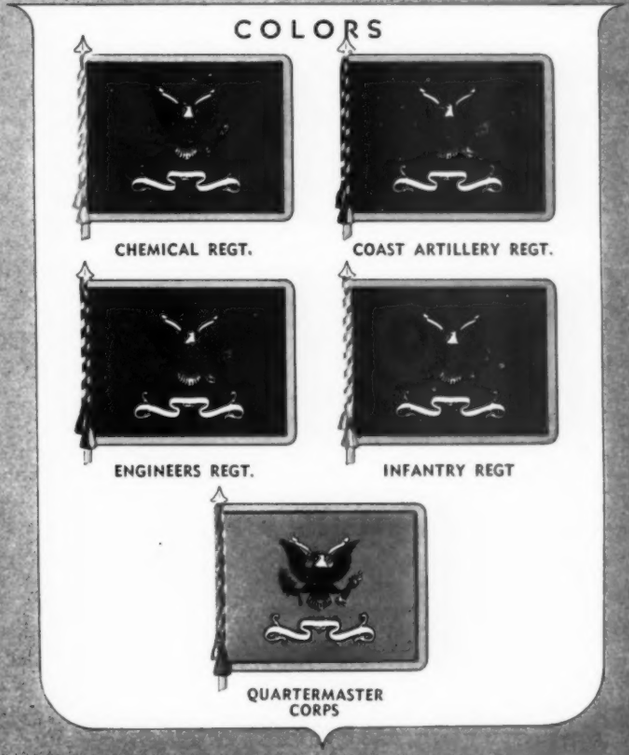
Regiments having an approved badge, but no coat of arms, place the badge above the eagle's head, but do not place a shield on his breast.

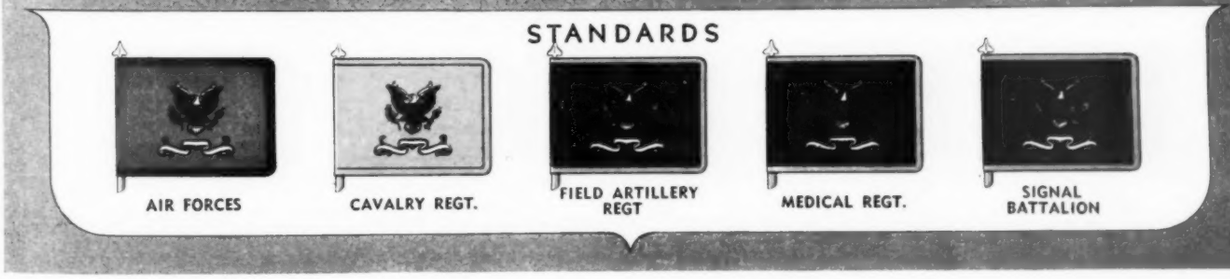
Attached below the spearhead of the pike bearing the regimental color is an eight-foot cord with tassels, of the same colors as the regimental color.

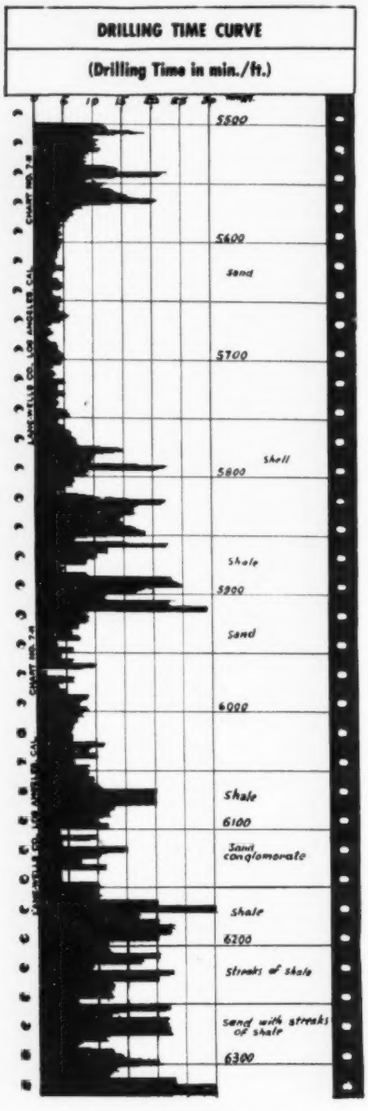
*Observer's left.
**Observer's right.

HUGHES TOOL COMPANY
HOUSTON, TEXAS


GENERAL OF THE ARMIES
CHIEF OF STAFF
COMMANDING GENERAL ARMY GROUND FORCES
COMMANDING GENERAL ARMY AIR FORCES
COMMANDING GENERAL SERVICES OF SUPPLY







(Courtesy Lane-Wells Company)

Fig. 2. Rate-of-penetration log produced by Lane-Wells drilling-time recording instrument

pressures, rotational speeds, pump pressures and other conditions of drilling control.[7] Studies of this character are helpful in increasing drilling efficiency. Drilling-time records are also of assistance in determining where cores may advantageously be taken before the opportunity to do so has passed, and they will be of help in interpreting the results of coring when only partial recovery of the core is obtained. Firm strata in which to land casing may be chosen on the basis of the rate-of-penetration record.

Caliper Logging

Though the size of bit and drilling conditions may be maintained constant throughout a depth interval, the diameter of the well will vary with the character of the formations penetrated. Soft, unconsolidated and semi-consolidated formations tend to cave or are jetted or eroded away by the circulating drilling fluid, leaving the diameter of the well considerably larger than that of the bit with which it is drilled. In hard, well indurated formations, the diameter of the well is but little larger than that of the bit. Cavities of considerable size are sometimes formed by erosional influences, by influx of sand into the well with flowing gas or oil, or by use of explosives, or by acid treatment of limestones. A record of variation in bore of the well throughout an interval will thus yield information from which changes in the lithologic character of the strata penetrated may be inferred. Knowledge of the diameter of the well at different depths is also helpful in planning various subsurface operations, as in cementing casing, gravel-packing or selecting and installing packers.

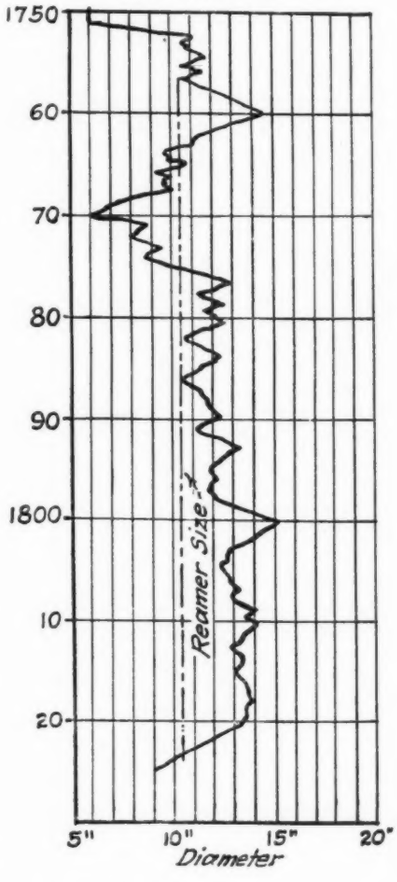
Recently, a device has been developed, designed to be lowered into the well on a wire line, which measures the diameter of the hole at all depths.[11] This is the well "caliper", now made available to the industry on a service basis by the Halliburton Oil Well Cementing Co. The caliper instrument has four collapsible arms, mounted 90° apart on a steel frame, each arm independently of the others, being extended outwardly against the wall of the well under the tension of a spring. The instrument is lowered on the suspending wire line to the bottom of the interval to be logged, with the arms in collapsed position. The arms are then released and the instrument slowly raised through the well. The supporting line passes over a measuring reel that indicates the depth of the instrument at all times. As it moves upward, the ends of the arms maintain continual contact with the wall of the well. By electrical means, the position of the arms with respect to the axis of the instrument is at all time indicated on an instrument at the surface, which records directly the diameter of the well in log form against a depth scale. Fig. 3 is illustrative of the type of record obtained.

Applications of caliper logs. Caliper logs are particularly helpful in planning well cementing operations. In plugging wells with cement, it is necessary to know the volume of the well through a certain depth interval; or, in cementing casing, the volume of the annular space between the casing and the wall of the well through the interval to be cemented, must be determined. This is not ordinarily known with any degree of accuracy because of local variations in the bore of the well. In planning cementing operations, it has been customary to assume a diameter for the well equivalent to that of the bit with which it was drilled. In some cases, a certain percentage is then added to the computed volume to cover assumed but unknown variations. Surveys made with the well caliper have shown, however, that the actual volume of the hole is usually considerably greater than would be calculated on the basis of bit diameter. In some instances, three times as much cement has been found necessary to fill a given depth interval as the bit-diameter basis of computation would indicate. A caliper log affords information from which the amount of cement necessary can be computed with fair accuracy, and thus we may be assured that the space which we desire to fill with cement will be completely filled and waste of cement due to over estimates can virtually be eliminated.

Much the same problem is presented in gravel-packing well cavities through productive formations. Perhaps the well cavity has been formed by means of explosives, by acid treatment or by hydraulic means or wall scraping and its actual size may be unknown. The caliper log affords data with the aid of

Fig. 3. Caliper log made preparatory to gravel-packing a well

(After C. P. Parsons)



HOW *Longer-life Flupacos* CAN HELP IN WARTIME!

WILL *the pump you buy today still be on the job a year from now . . . and the next year . . . and the next?* If it's a new Flupaco pump, you can be sure of *longest* possible service, *least* possible maintenance, because these pumps today are outwearing many others as much as *5 to 1* under the toughest kind of pumping conditions. That's a performance point *vitally important* in your wartime pump maintenance program. Look at these Flupaco features:

ONE-PIECE BARREL
—entirely eliminates disadvantages of jacket-plus-liner construction, gives higher production efficiencies.

SPECIAL HEAT TREATMENT
—makes full-length barrel 4 to 8 times harder on its wearing surfaces, doubles and triples service life.

MIRROR-FINISH HONING
—insures smooth, effortless plunger operation in barrel under all kinds of pumping conditions.

PRECISION ALIGNMENT
—eliminates uneven stroking because of free plunger travel.

FEWER REPLACEMENTS
—simple design reduces bulk, cuts weight in many cases to one-fourth of other pumps, eliminates *all* unnecessary parts.

So for your long range production program today, use top-performance Flupacos, pumps that are replacing bulky, costly types and streamlining entire production operations. Long-lived Flupaco "Groove Seals" and "Improved Insert" Pumps are available in a range of sizes, types, and metals for all conditions—and they're just as economical to *buy* as they are to *use*. See your Fluid Packed Pump representative—or write us direct—today—for the full details!

FLUID PACKED PUMP COMPANY, BOX 64, LOS NIETOS, CALIFORNIA

2 S. E. 29th ST., OKLAHOMA CITY, OKLA. ★ HUNT BLDG., TULSA, OKLA. ★ 2301 CONGRESS AVE., HOUSTON, TEXAS

WORLD'S LARGEST EXCLUSIVE OIL WELL PUMP MANUFACTURER

FOUR TIPS ON PUMP MAINTENANCE

to make present equipment last longer

1 Careful transportation:

Crate your pumps for long hauls, and handle carefully to avoid bending. Don't pile heavy objects on top of pumps, and make sure they are placed on a flat surface or are supported at close intervals. Wrap ends, but do not remove shipping or data tags.

2 Inspection:

After removing a pump from the well, clean it as quickly as possible to avoid unnecessary rusting. Lay pump flat on bench and inspect thoroughly. Check condition of pump anchor seat, and all accessible ball valves and seats. Use hydraulic pump to free sanded plunger. Use wrench flats provided when unscrewing parts, with end-wrenches to fit. Avoid applying excessive pressure or torque.

3 Repair and Reassembly:

Replace all worn parts with new ones, working with wrenches close to mating surfaces. Do not make up parts with excessive pressure—clean and lubricate threads first to avoid need for heavy strains. Make sure all valves are in proper position. When reassembled, tag and identify pump, giving all important specifications.

4 Systematic Storage:

Before storing, make sure all parts subject to rust are well oiled, greased or wrapped. Wrap accessories in moisture proof paper. Store so that pumps cannot be damaged.

which the amount of gravel necessary to fill the cavity can be computed accurately. The contour of the wall of the well through a producing horizon may be a succession of projecting ledges with intervening intervals of larger diameter representing the strata of softer texture that are more readily disintegrated by the forces operative. It may be important to know with accuracy the location of the projecting ledges in order that gravel may be disposed between them without leaving unfilled voids.

In acid treatment of producing formations, it is important to know the comparative permeabilities of different component beds of the formation to which the acid has access. The strata that have yielded most to the disintegrating influences of drilling and production appear on the caliper log as the intervals of largest diameter, and are likely to be composed of the more permeable beds which will absorb acid most readily. Packers may be set to exclude these strata in order to confine the acid to the beds of lesser permeability.

In setting packers to close the annular space between casing or tubing and the wall of the well, it is important to set the packer against firm rock in a hole of diameter in which the packer has been designed to function. Expensive packers, manufactured to precision dimensions, often fail to serve their intended function because they are set in a hole larger than that for which they have been designed.

Caliper logs usually present a succession of peaks and "valleys", forming a profile that is characteristic of the sequence of formations penetrated by the well. When formations are regular and continuous, caliper logs of different wells in the same locality often display very similar profiles, so that it is possible to correlate formations from well to well with fair certainty. Marker beds and reference horizons in the section often present an abrupt change in lithologic character of the beds that is clearly expressed in the caliper log.

In drilling through formations containing soluble salts, the well bore may be materially increased by solution in the drilling fluid, of the material exposed in the wall of the well. A timely caliper log will disclose this condition and suggest changes in character of the drilling fluid to minimize the difficulty.

Recently developed methods of sidewall coring involve use of tools that are designed for successful operation only when the wall of the well is within a few inches of the coring tool. A caliper log will disclose intervals in which such devices may be used to advantage.

Selected Bibliography

Drilling-time and Rate-of-Penetration Records

1. "Record of Penetration Rate Should Aid in Drilling-Time Studies," by H. L. Flood, *The Petroleum Engineer*, October, 1939, page 31.
2. "Drilling-Time Studies as an Aid in Providing Accurate Knowledge of Formations," by H. L. Flood, *The Petroleum Engineer*, July, 1940, page 23.
3. "Lane-Wells Drilling-Time Recorder," Lane-Wells Co., *Tomorrow's Tools Today*, Vol. VII, No. 10, 1941, page 4.
4. "Application of Time Logs to Porosity Studies in Central Kansas Wells," by J. P. McKeep, *Oil & Gas Journal*, September 3, 1942, page 56.
5. "Automatic Geolograph Correlates Drilling Speed with Other Pertinent Data," *Oil Weekly*, Vol. 93, No. 5, page 11 (1939).
6. "New Drilling-Time Recorder Provides Effective Well Log," by W. A. Sawdon, *The Petroleum Engineer*, November, 1941, page 29.
7. "Rate of Penetration Record Facilitates Drilling," by W. A. Sawdon, *The Petroleum Engineer*, Annual Number, 1942, page 71.
8. "Rate of Penetration in Drilling," by K. C. Sclater, *The Petroleum Engineer*, June, 1940, page 47.
9. "Drilling-Time Logs and Their Uses," by R. Willis and R. S. Ballantyne, Jr., *Bulletin, American Association Petroleum Geologists*, Vol. 26 (1942), No. 7, pages 1279-1283.
10. "Practical Utilization of Rate-of-Penetration Drilling Data," by C. A. Yeatman, *American Petroleum Institute Production Bulletin 225*, May 27, 1940, pages 50-56.

Caliper Logs

11. "Caliper Logging," by C. P. Parsons, *A.I.M.E. Tech. Paper 1474; Petroleum Technology*, May, 1942, 8 pages.

Temperature Logs

12. "Thermal Logging of Producing Oil Wells," by C. R. Dale, *Oil & Gas Journal*, March 19, 1942, page 49. A.P.I. paper.
13. "Geothermal Gradients in California Oil Wells," by R. W. French, *A.P.I. Drilling & Production Practice*, 1939, pages 653-658.
14. "Location of Water Flows in Drill Holes by Temperature Measurements," by H. Guyod, *Oil Weekly*, June 29, 1936.
15. "The Economic Utility of Thermometric Measurements in Drill Holes in Connection with Drilling and Cementing Problems," by F. G. Leonardon, *Bulletin, Society of Petroleum Geophysicists*, January, 1936.
16. "The Lane-Wells Temperature Recording System," by R. W. Lehman, Mimeo pamphlet distributed by Lane-Wells Co., Los Angeles, Calif., 9 pages.
17. "Temperature Surveys in Oil Wells," by C. V. Millikan, *A.I.M.E. Petroleum Development and Technology, 1941*, pages 15-23. See also, Tech. Paper 1258, *Petroleum Technology*, November, 1940.
18. "Temperature Log Reveals Gas-Oil Contact Plane," by W. A. Sawdon, *The Petroleum Engineer*, September, 1940, page 83.
19. "Application of Well-Test Data to the Study of a Specific Gas-Production Problem," by M. A. Schellhardt, E. J. Dewees, and W. H. Barlow, U. S. Bureau of Mines, Rept. of Investigation No. 3493, April, 1940, 22 pages.
20. "Accuracy in Temperature Surveys Necessary for Successful Application," by B. Winter, *Tomorrow's Tools Today*, Vol. VIII, No. 1, 1942, pages 20-23. Lane-Wells Company.

Logging by Inspection of Drilling Fluid

21. "Baroid Well-Logging Service," Baroid Sales Div., National Lead Company, 15-page pamphlet, 1940.
22. "Mud Analysis as a Basis for Well Logging," by H. L. Flood, *The Petroleum Engineer*, September, 1941, page 21.
23. "Continuous Logging at Rotary-Drilled Wells," by J. T. Hayward, *A.P.I. Drilling & Production Practice*, 1940, pages 8-19.
24. "Mud Analysis Used to Log Wells While Drilling," by W. A. Sawdon, *The Petroleum Engineer*, August, 1939, page 84.
25. "Mud Analysis Logging in California Fields," by W. A. Sawdon, *The Petroleum Engineer*, Annual Number, 1942, page 48.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer*.

☆ ☆ ☆

Application Regarding Texarkana Gas Condensate Pool Denied

Application by the Arkansas Oil and Gas Commission for authorization to use material for the development of the Texarkana gas condensate pool, Miller County, Arkansas, upon the basis of one well to each 160 surface acres, pursuant to the provisions of paragraph (c) (10) of Conservation Order M-68, as amended, has been denied by the Petroleum Administration for War.

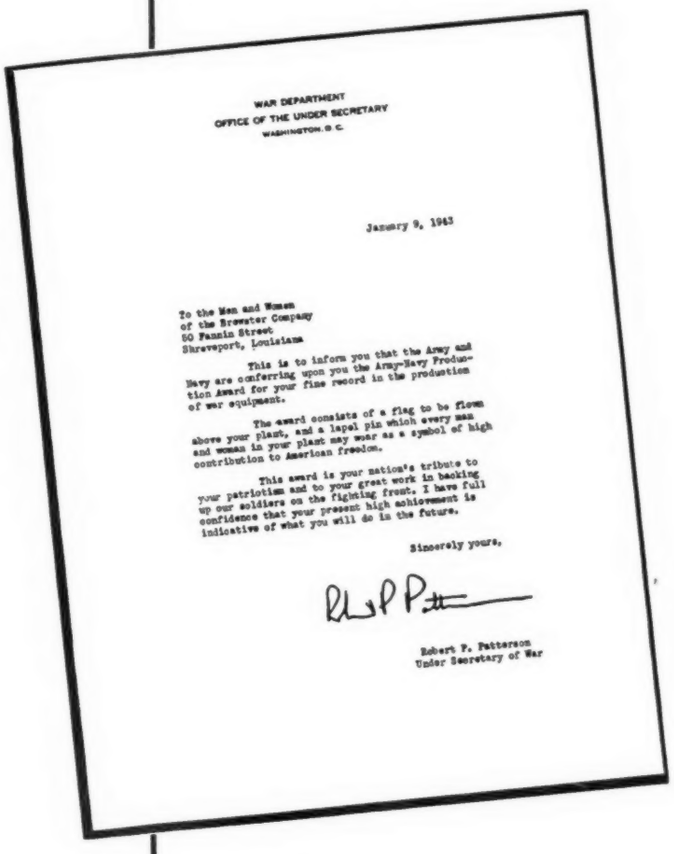
In a recent letter to O. C. Bailey, chairman, Arkansas Oil and Gas Commission, Robert E. Allen, assistant deputy Petroleum Administrator, said:

"It is regretted that on the basis of the data submitted in your application, because there is no outlet at present for the gas as such, and because of the necessity to minimize the expenditure of critical material, your application is denied."

The BREWSTER COMPANY

AWARDED

ARMY-NAVY "E"



WAR DEPARTMENT
OFFICE OF THE UNDER SECRETARY
WASHINGTON, D. C.

January 9, 1943

To the Men and Women
of the Brewster Company
50 Fannin Street
Shreveport, Louisiana

This is to inform you that the Army and Navy are conferring upon you the Army-Navy Production Award for your fine record in the production of war equipment.

The award consists of a flag to be flown above your plant, and a lapel pin which every man and woman in your plant may wear as a symbol of high contribution to American freedom.

This award is your nation's tribute to your patriotism and to your great work in backing up our soldiers on the fighting front. I have full confidence that your present high achievement is indicative of what you will do in the future.

Sincerely yours,

Robert P. Patterson

Robert P. Patterson
Under Secretary of War

Our sincere thanks to all those loyal customers who have been so uniformly patient and considerate while we take time out to make fighting equipment for fighting men. We'll be back on the job when this fight is won.

Meantime, please let us have your inquiries for BREWSTER equipment. We can still make delivery on many items.

DRILLING RIGS • ROTARIES • DRAW WORKS
SWIVELS • BLOCKS • CORE BARRELS • REAMERS
FLOW BEANS • CASING HEADS • TUBING HEADS
WINCHES • REELS • BITS • WELL HEAD ASSEMBLIES

The BREWSTER COMPANY, INC.

SHREVEPORT, LOUISIANA, U.S.A.
EXPORT OFFICE: ACME WELL SUPPLY COMPANY
19 RECTOR STREET • NEW YORK, N.Y.

P 624.5
P 773.53

Certain Aspects of Cooling Tower Design and Operation*

☆ Principal methods of evaporative water cooling discussed

Part 1

by R. C. Kelly
Engineer, The Fluor Corporation, Ltd.

MUCH of the material presented on the subject of cooling towers has presumed that the reader had a working knowledge of the evaporative phenomena and the basic elements of cooling tower design. In view of the fact that today new men are being called into new jobs and that these men may welcome a review from the "bottom up," this article discusses briefly each of the principal methods of evaporative water cooling.

Although industrial water cooling has apparently progressed through definite stages in the use of cooling ponds, spray ponds, spray coolers, atmospheric deck-type towers, and mechanical draft-type towers, it cannot be conclusively stated that any one method is universally better than another. Rather, each has its own application and relative advantages and disadvantages. To analyze these relative merits and at the same time develop a background for the discussion of the comparison of atmospheric and mechanical draft towers, certain data for cooling ponds, spray ponds, and spray coolers will be discussed briefly.

The principal factors entering the analysis are: The initial temperature (t_1) of the hot water entering the unit; the wet bulb temperature (t_{wb}) of the air entering the unit; the quantity of air (or velcoity) passing over the surface of the water, and the final temperature (t_2) of the water leaving the apparatus. With respect to any particular quantity of water to be cooled, the size and design of the cooling apparatus is determined by proper consideration of each of the following factors:

(a) Range of temperature through which water must be cooled.

(b) Approach of the cold water temperature to the wet bulb temperature.

(c) Mean maximum (or otherwise selected) atmospheric wet bulb temperature at which the required cooling must be done.

(d) Time of contact of air and water, determining the proportions of the structure as to height, length, and concentration of water.

(e) Surface area (film surface) of water exposed to particular quantity of air entering the apparatus.

(f) The relative velocity and direction of air movement with respect to water movement.

*Presented at California Natural Gasoline Association, Monthly Meeting, Downey, California, December 3, 1942.

R. C. KELLY

attended Purdue University, majoring in mechanical engineering, and graduated from University of Arizona with degree of bachelor of science in mechanical engineering—After graduation he took over an operating business including The General Electric Company line of air-conditioning and industrial refrigeration in southern Arizona and in 1936 moved to the distributor's office in San Diego as industrial engineer—Soon after transferring to the Los Angeles distributor's office in 1937 as commercial department office manager, he left the refrigeration field to specialize in cooling tower production for the Pacific Tank and Pipe Company—After two years of oil-field construction work he became associated with the Cooling Tower Division of The Fluor Corporation, Ltd., Los Angeles, California, as a cooling tower sales engineer.

Cooling Ponds

The cooling pond or reservoir, now used principally for small heat load systems in which the heat exchange surface is designed for low temperature rise of the circulating water, can be quickly estimated by determining the amount of water evaporated under the design conditions. One approximating method of solution, using Box's formula, determines the grains of moisture, G, evaporated per hr. per sq. ft. of horizontal water surface, assuming still air, and assuming an average temperature rather than an integrated value.

$$G = 240 + 3.7\left[\frac{t_1 + t_2}{2}\right](P_s - P),$$

in which P_s is the pressure of the saturated vapor in in. of Hg. corresponding to the average temperature

$$\left[\frac{t_1 + t_2}{2}\right]$$

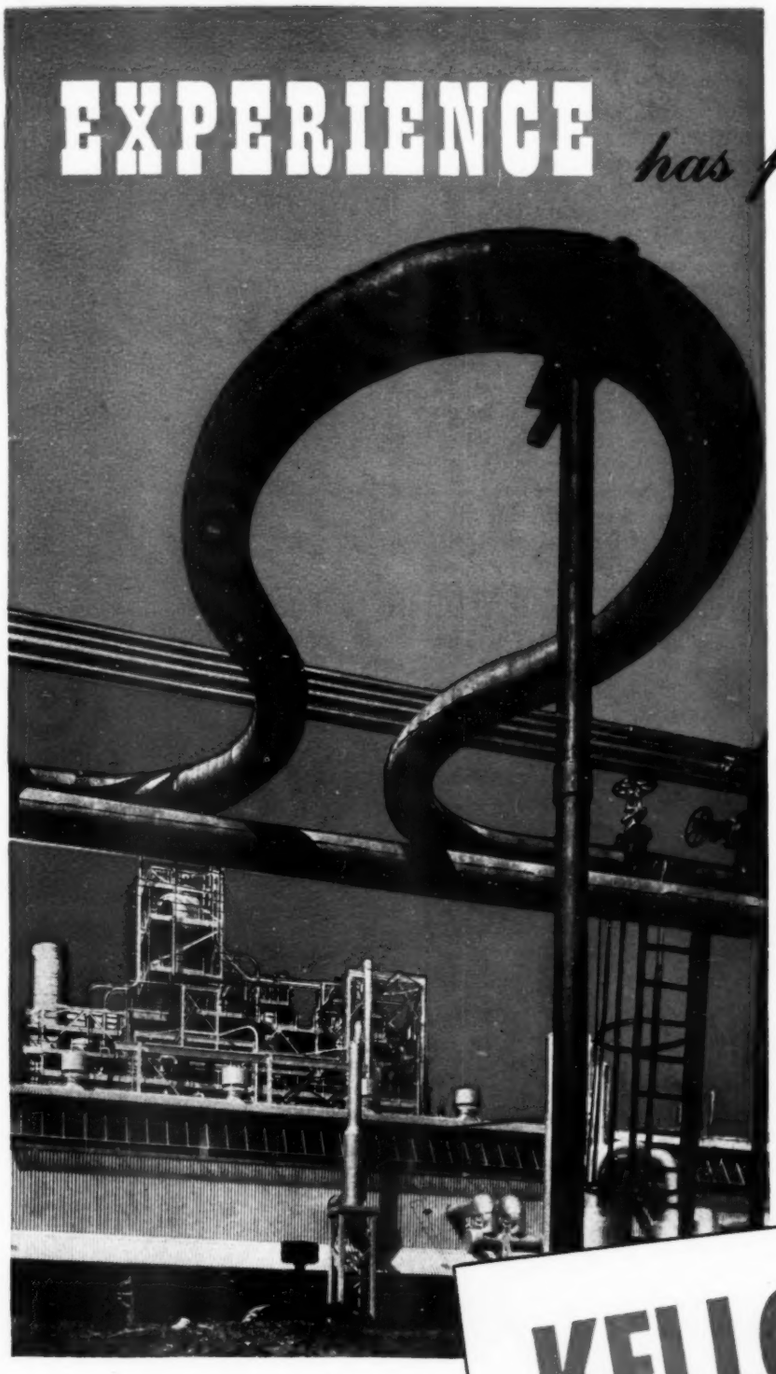
of the circulating water in °F., and P is equal to the actual vapor pressure of the air in in. of Hg.

From the basic physical equation

$$\frac{\text{B.t.u. per hr.}}{\text{min. per hr.} \times \text{lb. per gal.} \times (t_1 - t_2)} = \text{g.p.m.},$$

cooling 100 g.p.m. from 95°F. to 85°F. would dissipate approximately 500,000 B.t.u. in one hour. For this example we assume a wet bulb of 75°F. and a dry bulb temperature of 80°F. This fixes the relative humidity at 80 percent, for which condition we find from the steam tables that $P_s = 1.421$ at $\left[\frac{t_1 + t_2}{2}\right] = 90$°F.; and $P = 1.032 \times 0.80 = 0.825$ at 80 percent relative humidity. Substituting in Box's formula we then find $G = [240 + (3.7 \times 90)](1.421 - 0.825) = 342$ grains moisture evaporated per sq. ft. per hr. Also from steam tables we find that 1041 B.t.u. are required to evaporate 1 lb. of water from and at 90°F.

Then, as 7000 grains equal 1 lb., $\frac{342}{7000} = 0.049$ lb. H_2O; $0.049 \times 1041 = 51$ B.t.u. per sq. ft. per hr. heat loss from



EXPERIENCE *has proven invaluable*

Kellogg's years of experience in contributing to refining progress have enabled refiners to meet the changes necessitated by global war.

Kellogg-built plants are today helping to "Keep 'em flying" and "Keep 'em Rolling."

KELLOGG DESIGN, CONSTRUCTION and LICENSING

- Catalytic Processes for Cracking, Hydroforming, Reforming, Dehydrogenation, Alkylation, Desulphurization
- Gasoline Products Company, Inc. . . . . Pyrolytic Cracking
- The Polymerization Process Corporation, Thermal & Catalytic Polymerization
- JUIK Processes . . . . for Lubricating Oil Refining with Propane and Phenol-Deasphalting-Dewaxing-Solvent Extraction and Acid Treating Plants

THE M. W. KELLOGG COMPANY · JERSEY CITY, NEW JERSEY · 225 BROADWAY, NEW YORK
Los Angeles: 609 South Grand — Tulsa: Philtower Building

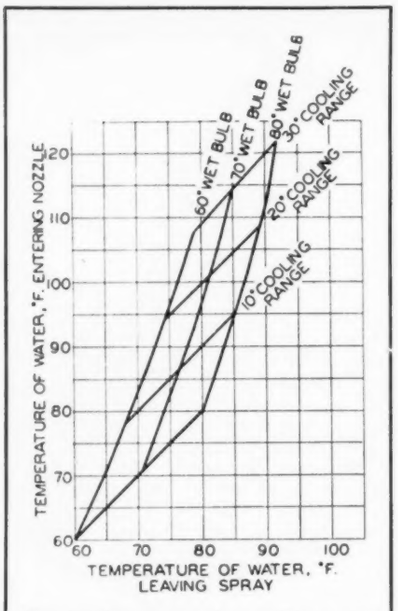
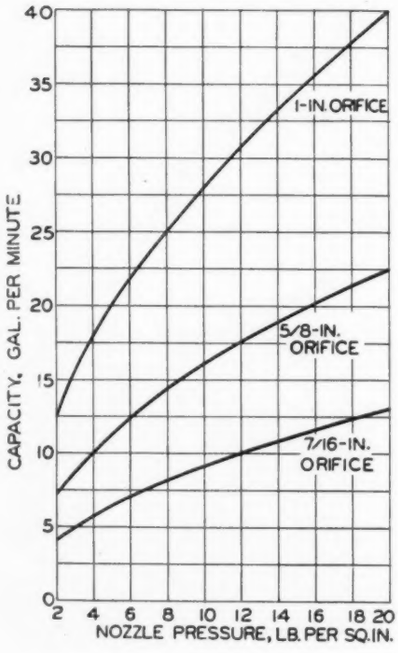


Fig. 1. Spray nozzle cooling curve —5 mi. per hr. wind velocity, 7 lb. per sq. in. nozzle pressure, and 1-in. orifice nozzle

the quiet surface of the pond. This corresponds to $\frac{51}{95 - 85} = 5.1$ B.t.u. per sq. ft. per hr. per °F. cooling range. Therefore, to accomplish the desired cooling 100 g.p.m. × 8.33 lb. per gal. × 10° cooling range × 60 min. per hr. = 500,000 B.t.u. per hr., removal necessary. Then the area of pond required to dissipate 500,000 B.t.u. per hr. would equal $\frac{500,000}{51} = 9800$ sq. ft., which is equal to 0.102 gal. degrees per sq. ft. This determination of required area assumes a zero wind condition. Consequently any appreciable movement of air in addition to that movement induced by differential densities would increase the rate of evaporation and thereby increase the cooling capacity of the pond.

Fig. 2. Spray-nozzle capacities



Spray Ponds

If this same heat load is to be handled by the same quantity of circulating water, and a system of spray nozzles installed above the surface of the pond —a spray pond with the nozzles discharging vertically—the same procedure could be followed to determine the required spray area *if* the total effective area (film surface) of the drops of water was determinable. This information is unavailable at this time and without it purely theoretical determination is inaccurate. For this reason empirical data —the results of field operating experience—are the sole source of design information.

A so-called "cooling curve" for spray ponds is shown in Fig. 1, in which one particular type nozzle at one particular pressure is rated for a 5-mile per hour wind condition. In Fig. 2 various nozzle capacities for several pressures are shown, each one of which requires a typical cooling curve for design analysis.

To better show the advantages of spray nozzles over a flat pond, assume a total heat load 10 times as great as the first example, and a cooling range from 95°F. to 85°F. when the wet bulb temperature is 80°F. Circulation of 1000 g.p.m. must dissipate 5,000,000 B.t.u. per hr. From the nozzle capacity chart we find that a typical 1-in. orifice nozzle at 7 lb. per sq. in. pressure will deliver 23 g.p.m. Then $\frac{1000}{23} = 44$ nozzles will be required. Average spacing of nozzles, in groups or clusters, would require an area of approximately 4000 sq. ft. This then shows $\frac{5,000,000}{4000} =$ 1250 B.t.u. dissipation per sq. ft. per hr. of horizontal effective area of the apparatus, or 2.5 gal. degrees per sq. ft. This represents an increase in cooling capacity of from 51 B.t.u. per sq. ft. per hr. to 1250 B.t.u. per sq. ft. per hr., which increase in space efficiency may be partially offset by increase in costs of the equipment and pumping.

Spray Coolers

Operators of spray ponds found that in the periods of just average wind conditions a drift loss of from 5 to 10 percent of the circulation was common. This was expensive in water cost, and often damaging to adjacent property and equipment. The result was the installation of louver fences around the pond. Thus the development of the spray cooler, an apparatus that is louvered on all sides, is from 6 ft. to 20 ft. in width and from 12 ft. to 30 ft. in height, in which small orifice nozzles

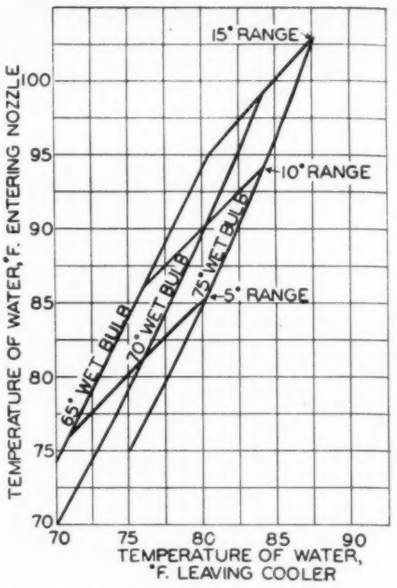
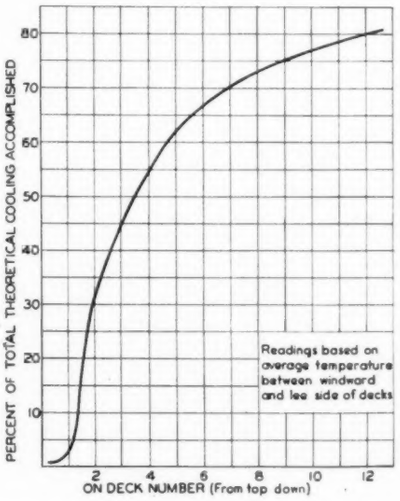


Fig. 3. Cooling curve for louvered spray cooler—5 mi. per hr. wind velocity; 6 lb. per sq. in. nozzle pressure

Fig. 4. Relation of cooling efficiency to number of decks for atmospheric louver-type tower 12 ft. wide and 35 ft. high.

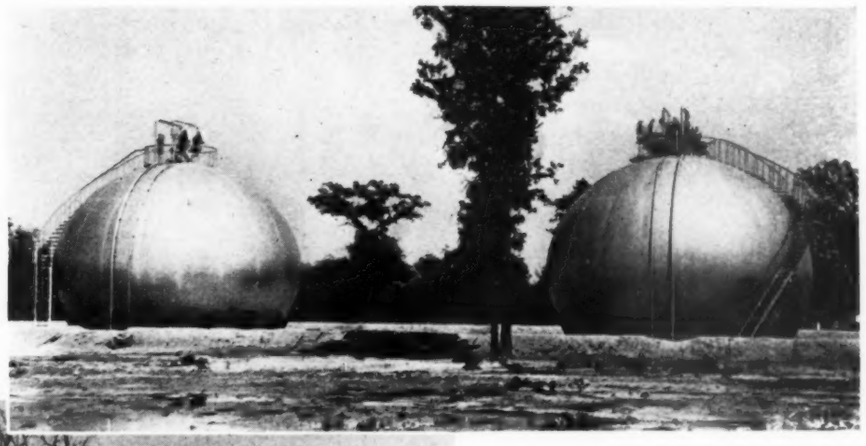
Conc. = 1.4 gal per min. per sq. ft. $t_1 = 82.3°$F. $t_2 = 69°$F. $t_{wb} = 65°$F.

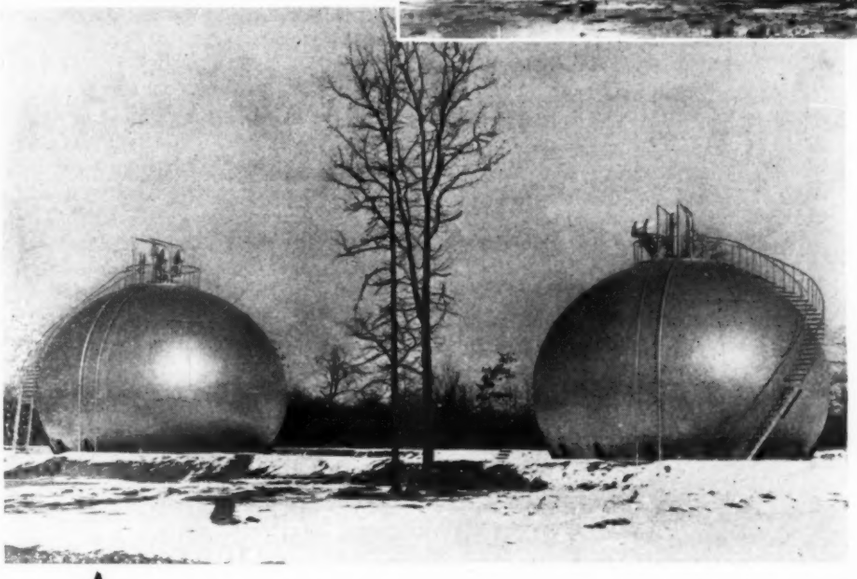
$$\text{Efficiency} = \frac{t_1 - t_2}{t_1 - t_{wb}} \times 100$$


PERCENT OF TOTAL THEORETICAL COOLING ACCOMPLISHED
Readings based on average temperature between windward and lee side of decks
ON DECK NUMBER (From top down)

HORTONSPHEROIDS

ELIMINATE VAPOR LOSSES *when* TEMPERATURES *vary*





Year 'round PROTECTION

A MAJOR CAUSE of vapor losses in the storage of volatile petroleum products is the variation between daytime and nighttime temperatures . . . a condition often as prevalent during winter months as at other times of the year.

The use of Hortonspheroids for the storing of volatiles provides positive protection against such losses. These pressure vessels are designed to withstand the pressures that result from normal temperature fluctations. Thus, Hortonspheroids eliminate breathing and boiling losses by eliminating venting — no vapor escapes into the atmosphere and no air is admitted to the vapor space. When temperatures rise the pressure in the vapor space builds up until it equals the vapor pressure of the liquid at that temperature. As temperatures drop, vapor pressure is reduced and excess vapor condenses.

The two Hortonspheroids illustrated are 5,000-bbl. units, part of the pressure storage facilities at a Texas recycling plant. One operates at 15 lb. per sq. in. pressure and the other at 20 lb. per sq. in. pressure.

CHICAGO BRIDGE & IRON COMPANY

San Francisco	1019 Rialto Bldg.	Havana	402 Edificio Abreu	Cleveland	2237 Guildhall Bldg.
Greenville	York Street	Houston	5622 Clinton Drive	New York	3368-165 Broadway Bldg.
Birmingham	1542 N. Fiftieth St.	Tulsa	1603 Hunt Bldg.	Philadelphia	1611-1700 Walnut St.
Chicago	2491 McCormick Bldg.			Washington	330 Bowen Bldg.

Fabricating Plants in BIRMINGHAM, CHICAGO, and GREENVILLE, PA.

spray directly downward at pressures ranging from 5 lb. per sq. in. to 20 lb. per sq. in. Greater efficiency was found to result when a finer spray of small, but not minute, drops was directed toward the basin than when a coarser spray of larger drops was developed by upward spray. This unit, like the spray pond, does not lend itself to simple mathematical analysis because of the difficulty in measuring the amount of film surface exposed to fresh air and the relative velocity of the air passing that surface. Fig. 3 shows a typical cooling curve for a spray cooler operating on 6 lb. per sq. in. pressure on downspray nozzles. A typical unit of this type would be rated for 1000 g.p.m. dissipating 5,000,000 B.t.u. per hr. through a 10° cooling range from 95°F. to 85°F. when a 5 mile wind and a 75°F. wet bulb prevailed. Here again a typical case is shown to develop the point. This unit would be 12 ft. wide, 16 ft. high, and 60 ft. long, or equivalent to a heat dissipating factor of $\frac{5{,}000{,}000}{12 \times 60} = 6950$ B.t.u. per sq. ft. per hr., or 13.9 gal. degrees per sq. ft.

Atmospheric Deck Towers

The next progressive structural step was the standard deck type atmospheric cooling tower. In these units the hot water is distributed over the top of the tower by troughs or pipes with nozzles attached, and as the water falls downward to the basin its fall is interrupted by a series of decks composed of wooden battens placed horizontally at intervals to break the water into the smallest possible drops and to appreciably increase the period of time of air-water contact. Design data for these units are again largely empirical, based on experience factors, and although deck design and vertical spacing vary somewhat from one make of tower to another, assuming equivalent film surface the thermal efficiency is quite comparable. For purposes of this discussion, however, a standard unit 12 ft. wide and 35 ft. high with horizontal decks spaced on 2-ft. 8-in. centers vertically will be the basic unit. This is a tower 12 decks high, in which the water starts at the top and falls downward from deck to deck in 12 "falls" of 2 ft. 8 in. each. Because of the greater temperature differential between the water and the air in the top of the tower, a greater heat transfer per unit of time occurs in the upper portion of the structure. As the water falls and cools the transfer rate decreases and the cooling in the lower portion of the tower is relatively less per unit of time. A graph of this variation in rate of transfer is shown in Fig. 4. An appreciable difference in cooling efficiency is noticeable between the windward side and the lee side of the tower due principally to the saturation of the air as it passes through the tower. This situation is the governing factor in determining the effective width of the structure. A structure too wide would permit the air to become saturated and therefore do no further evaporative cooling before it had reached the lee side. Most towers are now built in 12-ft. width and wind velocities as low as 1 mile per hr. normal to the long axis of the tower will show efficient cooling across the width of the tower.

The particular advantages of this unit over the cooling pond, the spray pond, and the spray cooler are the reduction in space required, the capacity for cooling the circulating water through greater ranges of temperature to within closer approaches to the ambient wet bulb temperature, and the saving in water as a result of adequate louvering on all sides of the structure.

To follow the comparison through, we shall assume a water load of 1000 g.p.m. and a required heat dissipation of 5,000,000 B.t.u. per hr.—a condition that results in a 10° cooling range as in the previous examples. A tower 35 ft. high, 12 ft. wide in effective deck area, and equipped with 12 decks spaced on 2-ft. 8-in. centers, 24 ft. long will cool from 95 to 85°F. when a 75°F. wet bulb exists and a 5 mile per hr. wind prevails at right angles to the long axis of the tower. The effective area in ground space amounts to only $12 \times 24 = 288$ sq. ft. This is equivalent to a heat dissipation rate of approximately 17,350 B.t.u. per sq. ft. per hr. or 34.7 gal. degrees per sq. ft.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer*.

☆ ☆ ☆

P 094.6

Extending Life of Multiple V-Belt Drives

IN the December issue of *The Petroleum Engineer* were published suggestions made by the Engineering Research Bureau of the Multiple V-Belt Drive Association, having as their purpose the education of power users in the proper procedure of selection, installation, and maintenance of multiple V-belt drives to obtain maximum life of V-belts. The following are additional suggestions by that organization:

Avoid drag of improperly lubricated bearings. Inadequately lubricated bearings result in abnormal friction, which causes an overload to be placed on the V-belt drive, resulting in shorter belt life. Be sure that bearings are neither under nor over-lubricated.

Don't use new V-belts with old V-belts. Old belts dry out to some extent and the surface rubber air-cures to a degree where the co-efficient of friction may be entirely different from new belts. Variations in cross-section, stretch characteristics, and elastic properties may seriously affect the overall life of a mixed set of belts. Moreover, it is difficult to match new belts with old belts regarding lengths.

Save discarded V-belts for emergency use. Often discarded or worn belts, if not ruptured or torn, can be used in emergencies or for temporary replacement. A matched set can frequently be made up of old belts that have been used on the same drive.

Avoid use of idler to put tension on V-belts. A properly designed multiple V-belt drive will not require an idler to deliver fully rated horsepower if proper tension can be maintained. The use of an idler is not recommended if it causes back-bend on belts, resulting in belt failure.

Don't let V-belts rub against stationary objects. Be sure that the belts are not permitted to rub against guards, boxes or other objects as the chafing will quickly remove the protecting rubber and fray the fabric and cords.

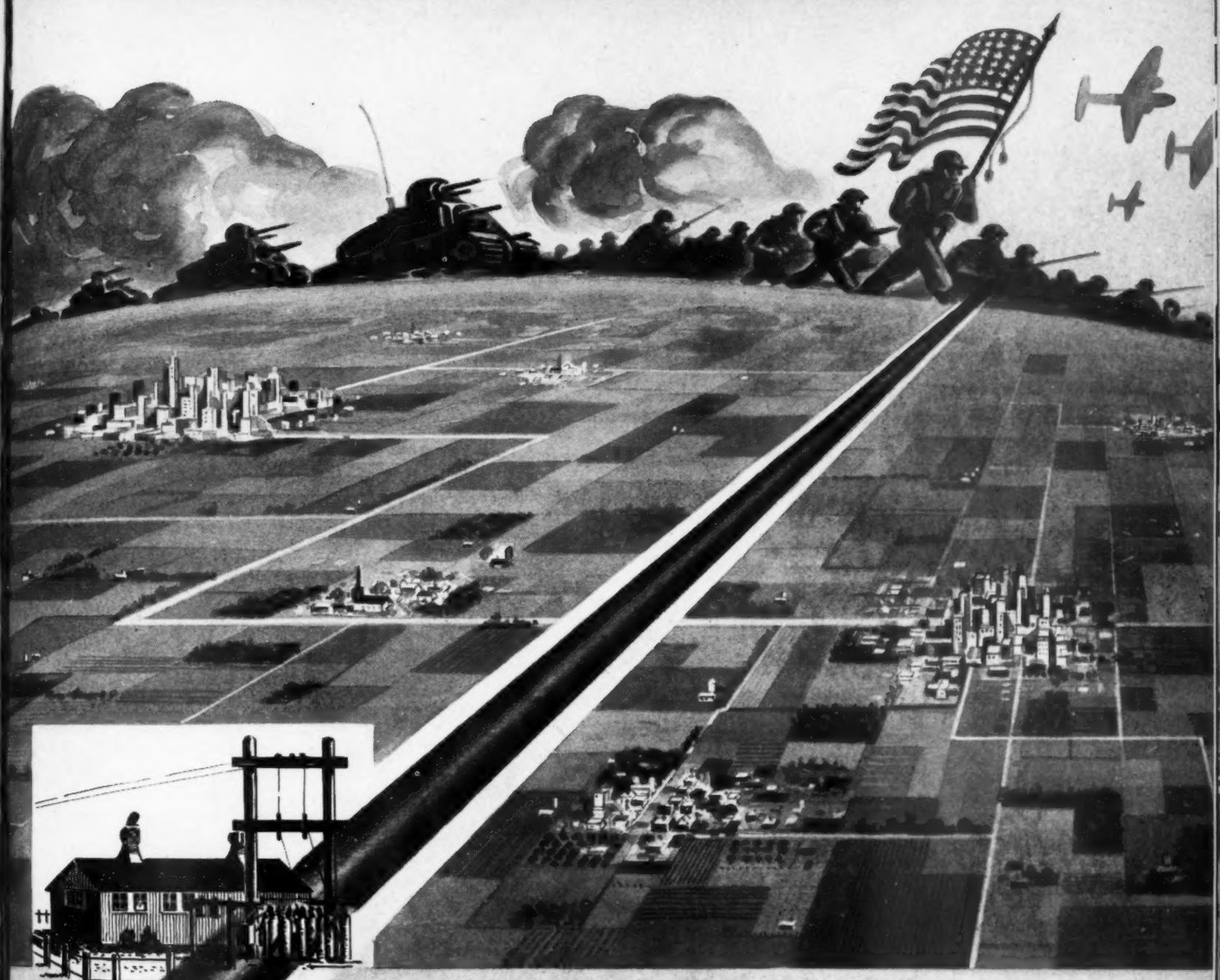
Store V-belts in a dry, cool stockroom. Reserve stocks of V-belts should be stored in a dry, cool, dark stockroom. The rubber will eventually become dried out if subjected to continuous heat.

Keep V-belt sheaves clean. Rust, dirt, and dust in V-belt sheaves will quickly wear away the protective rubber coating of the belts, and thus greatly shorten their normal life.

Don't operate V-belts in acid fumes or excessive moisture. Standard V-belts are not designed for the unusual service of operating in acid fumes or excessive moisture. If this condition cannot be avoided, ask the manufacturer for specific recommendations.

☆ ☆ ☆

LIFELINE of a nation at war



OUR JOB: to keep the life blood moving

Never in all history have Americans been so deeply aware of their dependence on petroleum. . . . Upon its availability at points of use rests the warmth of millions, the mobility of our war machine, the welfare of our fighting men, the progress of the war itself. . . . With these facts in mind, it is a privilege to report that practically <u>all</u> of Gaso's facilities are now enlisted in the war effort — directed to the single task of building the pumps that speed war-vital liquids to their destination. . . . Gaso Pump & Burner Mfg. Co., 902 E. First Street, Tulsa, Oklahoma. Export Office: 149 Broadway, New York. Los Angeles: Service Oil Field Supply Co., 5333 S. Riverside Drive.

GASO PUMPS

FOR EVERY OIL INDUSTRY NEED

P 511.222.

Bottom-Hole Choke Combines Automatic Safety Valve

PETROLEUM ENGINEER Exclusive Feature

☆ New dual tool provides subsurface safety valve protection and serves as bottom-hole choke — Streamlined construction prevents flow-cutting by high-pressure gas

by John O. Farmer

Engineer, Otis Pressure Control, Inc.

FOR several years prior to the entrance of the United States into the present conflict, hundreds of bottom-hole chokes and automatic safety valves had been installed in the Gulf Coast area—the bottom-hole chokes to avert freezing of the surface connections and the safety valves to prevent uncontrolled flow through the tubing in the event surface connections were damaged. It had been found, however, that the regular tubing safety valve, when used in combination with a bottom-hole choke, not only was difficult to adjust for closing at the desired rate of flow, but would not always function consistently. Consequently, during these years, safety valves were left out of the wells in which bottom-hole chokes were used. Although such practice was undesirable, the possibilities of damage during this time were primarily from stray barges and storms and it was hoped that if well connections were knocked off the bottom-hole choke would restrict the flow sufficiently to allow the well to be "manhandled."

After the United States entered the war, it seemed likely that attempts would be made to bomb and sabotage high-pressure fields in and around the Gulf of Mexico. Therefore, it became increasingly imperative that an automatic subsurface tubing safety valve be built that would give a positive shutoff and operate effectively in combination with a bottom-hole choke. With this objective in mind, several different designs and combinations of tools were given extensive tests. In all tests the results were unsatisfactory; however, the experiences and data obtained led directly to the construction of a completely new tool designed to overcome the defects found in the tools tested.

Preliminary Development

It was obvious from the beginning that a tubing safety valve, of the velocity or of the pressure differential type, would not function if placed beneath a bottom-hole choke, as failure of the surface connections in a high-pressure well normally has virtually no effect on rate of flow beneath the bottom-hole choke. The use of either type valve above a bottom-hole choke appeared practicable only if placed a considerable distance above a bottom-hole choke, so as to leave between it and the choke a considerable reservoir of gas to expand and flow at a greater than normal rate through the safety valve, should the surface connections be knocked off. Too, it appeared that damage to the well connections, which resulted in only comparatively slight leakage, might not cause the valve to close, as such leakage might only very slightly affect the rate of flow above the bottom-hole choke.

JOHN O. FARMER

graduated from the Missouri School of Mines, Rolla, Missouri, in 1933 with a B.S. degree in petroleum engineering—In 1942 he received an M.E. degree from the same school—After graduation in 1933 he joined the staff of The Carter Oil Company as a junior engineer and spent the succeeding two years in the Oklahoma City, Seminole, and Fitts fields of Oklahoma—In 1935 he became associated with Otis Pressure Control, Inc., Dallas, Texas, in an engineering capacity.

The first test was made in a well that produced a considerable amount of sand with an extremely high flowing pressure. The bottom-hole choke in this well was set at 5000 ft. A velocity type tubing safety valve was set at 1000 ft., leaving a 4000-ft. reservoir between the bottom-hole choke and the safety valve. An attempt was made to adjust the safety valve so that it would remain open only so long as the rate of flow at the surface did not exceed the capacity of the bottom-hole choke. Somewhat as anticipated, it was found that a gradual release of pressure at the surface would not always cause the valve to close, thus rendering it unreliable should the surface connections be damaged enough to result in only a small surface leak. It was also found that the high flow velocities resulting from the use of the bottom-hole choke caused both considerable chattering and cutting of the valve elements. These results proved this type of installation too unreliable for the purpose.

In an effort to alleviate the difficulties encountered in this first test, a combination tool was designed that consisted of a velocity valve built into the cage assembly directly above a spring-loaded choke bean. The purpose of this design was to allow the velocity valve to remain open so long as the flow through the tool was limited to the orifice in the choke bean. Should the pressure drop across the choke bean exceed that for which it was set, however, the choke bean would be raised from its seat and permit additional flow to pass around the bean. This additional flow

Enlarged reproduction free on request

Servant of Freedom

Mighty servant of all America is the Construction Industry. Its strength is the strength of our great quarries, mines and forests. Its driving power comes from our extensive oil wells and factories . . . and from the minds of men who dream of making an ever better world.

Now during war, Construction marches only against the enemy . . . but with Victory, Construction will again bring progress in its train.

Already the Construction Industry has brought us vast networks of highways, bridges and airports —to help free men from barriers of distance, time and transportation costs . . . massive dams are making low-cost electricity available to more and more millions, lifting old burdens . . . vast aquaducts and sanitation systems are contributing to our people's health.

With the return of peace, Construction will bring in its train ever new and greater contributions toward the better life for all.

★ ★ ★

Wickwire Rope is proud of the privilege of helping the Construction Industry in its engineering accomplishments . . . in quarries, on highways, in the building of dams, bridges, and structures of all kinds.

A CHALLENGE

The present shortage of steel, and of wire rope, challenges each member of the Construction Industry to make each length of wire rope now in service last longer than ever before. Every man who uses or handles wire rope can help.

We will be glad to furnish free copies of the helpful book "Know Your Ropes," which pictures the right and wrong ways to use wire rope. TAKE UP THE CHALLENGE—WRITE FOR YOUR COPY—AND MAKE SURE ANY NEW MEN KNOW THE *RIGHT* WAYS. . . . Address Wickwire Spencer Steel Company, 500 Fifth Ave., New York, N. Y.

COPYRIGHT 1943, WICKWIRE SPENCER STEEL COMPANY

WICKWIRE ROPE

Sales Offices and Warehouses: Worcester, New York, Chicago, Buffalo, San Francisco, Los Angeles, Tulsa, Chattanooga, Houston, Abilene, Texas, Seattle. Export Sales Department: New York City

WISSCO PRODUCTS

would cause the velocity valve to close and shut off all flow through the tool. As both the velocity valve and spring-loaded bean were adjustable, it seemed certain that the valve could be made to function as desired under almost any condition. Initial tests soon revealed, however, that although the spring-operated bean functioned perfectly and exactly as calculated, the velocity valve still could not be made to operate consistently. Also, as in the case of the first test, the accelerated velocity above the choke caused the valve elements to chatter and flow-cut badly.

It was next decided to try the more recently developed pressure-operated safety valve as a combination safety valve and bottom-hole choke. An orifice section containing an orifice the same size as the one used in the bottom-hole choke was installed in the safety valve and sufficient compression placed in the regulating spring to hold the valve open until a pressure drop of 1500 lb. per sq. in. was reached. The bottom-hole choke was pulled and the pressure-operated safety valve installed at 5000 ft. The valve operated perfectly at first, but after a few days use the orifice section and the valve and seat were cut out by abrasion of sand in the stream. After pulling the tool, it was found that the change of direction of flow through the orifice section and the location of the valve and seat immediately above the flow orifice had acted as flow baffles and were very conducive to flow-cutting. The pressure-operated safety valve simply had not been designed to carry a large pressure differential together with an abrasive flow.

These tests proved conclusively that a new tool incorporating the following features had to be designed if satisfactory results were to be obtained:

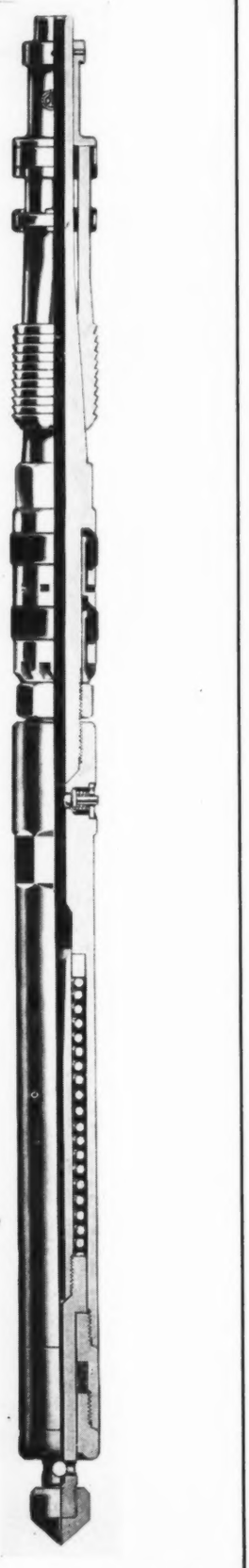
(1) Safety valve elements immediately below the orifice section and completely out of the direct line of flow.

(2) No operating obstruction or change of flow direction in or above the orifice section.

With these prerequisites in mind a new tool was designed that proved to be the most positive and versatile subsurface device of this nature yet developed. Not only is it being used in the more difficult jobs as a combination bottom-hole choke and safety valve, but also to perform the single function of either a safety valve or of a bottom-hole choke.

Description of New Tool

The type F Safety Valve is simple, yet very positive in action. It is essentially a small spring-loaded piston, through which an orifice is drilled to serve as a flow bean. On the lower end of the piston, and extending below the main body of the tool, is the valve.



Quarter-section view of tool showing locking mandrel, spring-loaded choke bean, and safety valve features

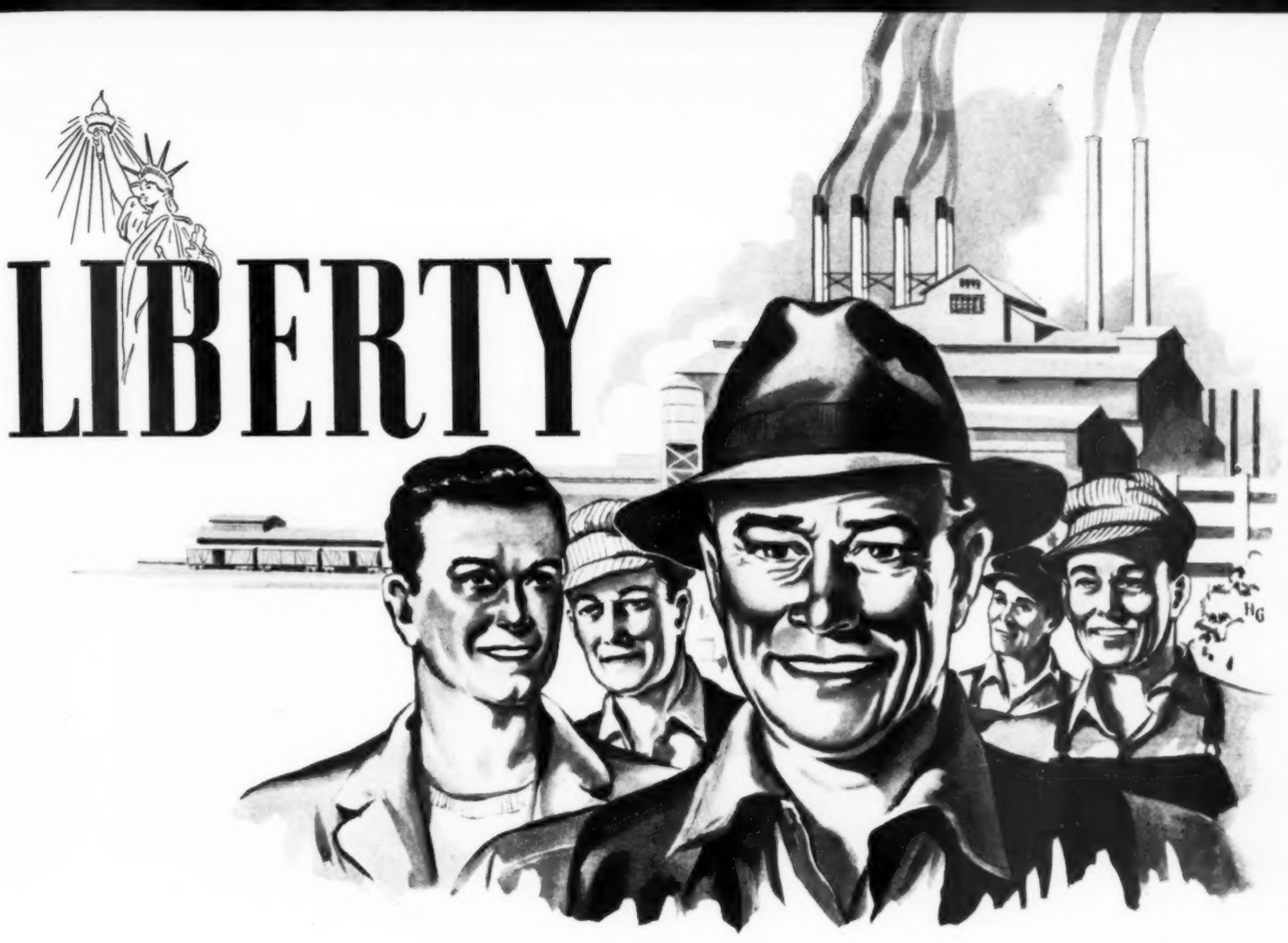
While open or in its downward position, the piston protrudes some distance below the main housing and permits flow to enter the flow bean through four horizontal ports in the piston, situated just above the valve. Pressure seal packing within the main housing prevents flow around the piston, and directs the entire flow through the bean. The piston is held in opened position by compression of the coiled spring, which acts to force the piston down against the upward thrust of the differential pressure. The instant the pressure differential for which the spring was adjusted is exceeded, however, the piston moves upward until the valve on its lower end engages the seat in the lower end of the main housing. This action shuts off all flow through the tubing. The tool, therefore, is operated entirely by pressure differential, and is not dependent upon flow velocities to actuate the valve. This feature eliminates completely the sensitiveness and inconsistencies that frequently cause trouble with velocity type valves. The type F valve mechanism has no more intricacies than has any ordinary piston assembly. Like other safety valves, it is opened simply by equalizing pressures across the valve.

General Field Practice

The type F Safety Valve has been used primarily in gas wells, condensate wells, and wells with high gas-oil ratio to prevent freezing in flow lines, and at the same time to provide protection against uncontrolled tubing flow. Generally, in these types of wells, the flow is directed into a high-pressure gas system or separator in which the pressure ranges from 600 to 1500 lb. per sq. in., and is usually nearly constant. Under these conditions, the practice is to compress the coiled spring to hold the piston in its opened position so long as the well is producing against the pressure maintained on the surface gathering system, but to close instantly should this surface pressure drop below a predetermined level. This arrangement provides an automatic subsurface shutoff in the event there is failure of or damage to surface connections.

New Construction Prevents Flow-Cutting

Probably the most important consideration given a tool of this type is the effect of abrasive action of the flow stream on the valve itself. This is most important when the valve is to carry a considerable pressure drop across the flow bean. The construction of the new valve is such that both the valve and valve seat are upstream from the bean where the velocities are relatively slower, and are completely out of the line of direct flow. The combined area



. . . *the Invincible Weapon of Free Men*

What is it that has made unprepared nations hang on against odds until they could get ready to battle the greatest armies ever gathered together in all history?

It is the deeply engrained feeling for freedom—the greatest force the Axis has confronted. Liberty is a fundamental spirituality that has given nations imbued with it enterprise, resourcefulness, initiative. Even with its head start the contrary philosophy of compulsion and regimentation is beginning to doubt its boasted invincibility. Liberty is a stronger bond than fear. Its authority springs from the free consent of the governed, while the authority of the Axis ideology is the will of the top gangmen who use their usurped power to enslave the masses.

What free enterprise can do is daily made manifest in the almost unbelievable mass production of ordnance and materials that is astounding our enemies. If there were those among us who ever doubted the innate power of the democratic way of life, their doubts have been dispelled. Now that people bound together by the bond of freedom have proved what they can do in the arts of war, they will go into the post-war era with high hopes.

Here at Mission we are putting into our war work the same engineering skill, the same precision techniques, the same ability to meet and beat schedules that has been a Mission tradition for many years. This "know-how" of free enterprise that is being repeated in industries all over America is the invincible weapon of free men.

MISSION MANUFACTURING CO.
HUMBLE ROAD HOUSTON, TEXAS

War Comes First

Buy Bonds for Victory and to insure a strong and stable United States when the war is over.

MANUFACTURERS OF:

Mission Slush Pump Valves—Mission Slush Pump Pistons—Mission Piston Rods—Mission Gland Packings—Mission Rotary Slips—Mission Swabs—Mission Plug Valves

of the four horizontal ports, through which the flow enters the bean, is several times greater than the largest bean used; therefore, these ports also are upstream and subjected to the slower flow velocities. The abrasive action of the flow stream entering the valve is greatly reduced by placing the four horizontal entrance ports at 90° angles. This causes the flow entering each port to deflect upwardly against the flow stream from the opposite port, thereby cushioning the change of direction made by the flow stream, and greatly reducing the cutting action at this point. The flow course, downstream from the bean, is one straight bore through the valve and mandrel assembly, and presents no cutting problem.

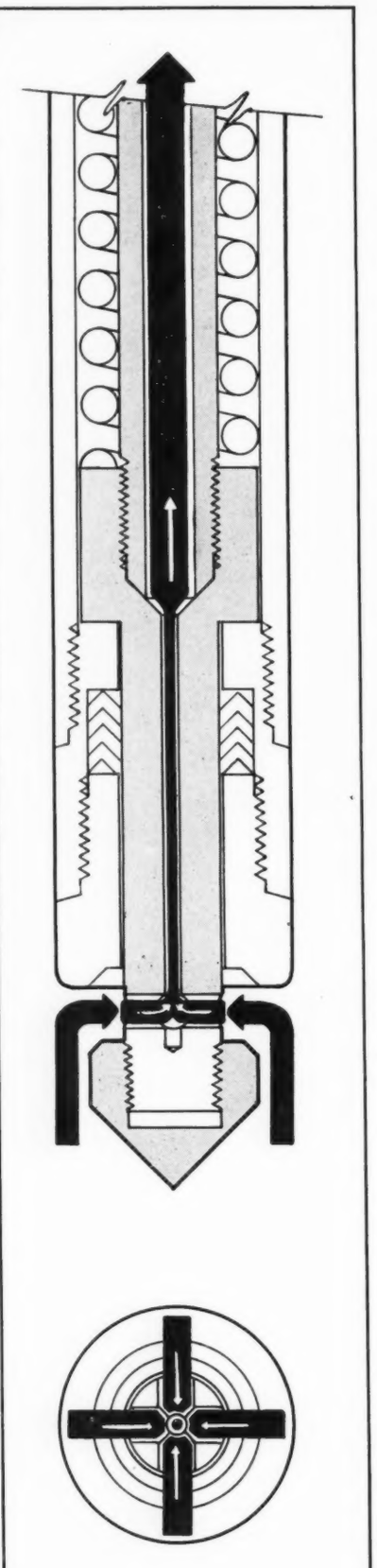
As in the case of the regular bottom-hole choke, the type F Safety Valve is set at a depth where the temperature of the flow stream is sufficiently high to absorb the temperature loss, due to the gas expansion, without causing freezing conditions in the flow stream.

Adjusting Valve

There are two opposing forces tending to actuate the valve; the mechanical force and downstream pressure acting downward to open the valve, and the upstream pressure acting upward to close the valve. The adjustment is made simply by sufficiently compressing the coiled spring to hold the piston in its downward position until a predetermined pressure differential is set up across the valve. The instant this condition is achieved, the upward force overcomes the force of the coiled spring, and the valve closes.

In selecting a pressure differential at which the valve is to close, it is necessary to determine the pressures above and below the valve at the closing point. The pressure below the valve, or the upstream pressure can be determined by observing the surface-flowing pressure when producing through a surface choke of the same size as that to be used in the safety valve and correcting this observed pressure for the depth at which the valve is to be set.

To determine the downstream pressure at the valve for closing, three factors must be considered; first, surface pressure at which it is desired that the valve close; second, back-pressure due to column of gas or fluid above valve; and third, pressure drop due to friction of flow in tubing after passing the valve. It is usually desirous for the safety valve to close at a pressure of 300 to 700 lb. per sq. in. under the lowest expected delivery pressure. This, of course, is to permit some fluctuations in trunk-line pressures. By multiplying the selected surface closing pressure by a correction factor for the density of gas and depth of valve, the weight of the column of gas above the valve can be determined. The drop in pressure due to friction of flow in the tubing above the valve is usually disregarded when the volume produced is less than 7,000,000 cu. ft. per day. When the volume exceeds this amount, however, a friction loss of 80 lb. per sq. in. per 1000 ft. of safety valve depth has been found to be sufficiently accurate for most installations. By adding the back pressure, caused by both the friction loss and the weight of the flow stream to the proposed surface closing pressure, the downstream pressure at the valve is determined. After the upstream and downstream pressures at the valve are determined, the differential pressure for which the valve is to be adjusted can be found by subtracting the downstream from upstream pressure.



Half-section view of bean and safety valve section showing streamlined fluid course through tool with automatic safety valve valve seat and valve completely out of the direct line of flow

To adjust the valve to close at the calculated pressure differential, the effective piston area against which the pressure acts must be considered. This is calculated by deducting the area of the orifice from the area of the piston. The upward force is determined by multiplying the effective area of the piston by the calculated pressure differential. This force must be offset by the mechanical force of the coiled spring. With the compression ratio of the spring known, it is easy to determine the width of the adjusting ring that will produce the proper initial compression in the spring.

It has been found good practice to test the adjustment on the surface before installation. This is accomplished by setting the safety valve in a lubricator on the well and closely observing the pressures above and below the valve as the gate on top of the lubricator is gradually opened. By subtracting the observed closing pressures, the actual pressure differential at which the valve will close is determined. This surface test often eliminates several trial round trips in and out of the hole, requiring considerable time.

Results

Results obtained from the use of this new tool have been most satisfactory. Its ability to perform two functions simultaneously, withstand extremely abrasive flow cutting, and operate positively and consistently under adverse conditions, makes the tool particularly adaptable for the high-pressure, deep-seated wells in and near the Gulf Coast. It is believed that this tool soon will be used very extensively not only for difficult jobs as a combination bottom-hole choke and safety valve, but also to perform the single function of either a safety valve or bottom-hole choke.

☆ ☆ ☆

then I said to myself—

EVERY WELDING INCH IS A "BIG INCH"

It's "BIG INCH" or Blockade *for Your Business*

"Big Inch" didn't just happen — Nazi subs FORCED it — by sinking tankers right and left —just when war industries and armed forces had zoomed demands on the East Coast. We had to do something BIG and QUICK.

ALTER EGO: Right! Our torpedo-firing "competition" forced our hand — forced us to build "Big Inch"—world's largest pipe line — 24" diameter, 1500 miles of it—big enough to pour 300,000 bbl. East Texas oil daily to the East Coast—equal to *150* 10,000-ton tankers.

And the record speed for building this record pipe line is made possible by welding.

ALTER EGO: Well, it's just the same story of competition with ships, planes, tanks, guns and all the other SPEED RECORDS made possible by welding. Competition forces progress.

But, what will take the place of present "competition" to FORCE the same records in speed, lower costs and improved designs in the post war Battle for Business?

ALTER EGO: Just plain sales competition will force change-over to the "Big Inch" method of construction. We'll change or we'll face business "blockade"! So we should start NOW on the right-of-way in welding knowledge if we ever *expect* profit in post-war business.

Ask your inner self whether it would be smart to get welding guidance, of "big inch" caliber, right NOW from

THE LINCOLN ELECTRIC COMPANY • CLEVELAND, OHIO

P 438.2
P 453.22

Gun-Perforation of Tubing

Exclusive

☆ Standard practice being developed that will aid in solving a variety of production problems

by Wallace A. Sawdon
Pacific Coast and Foreign Editor

ALTHOUGH the exigencies of the present oil production situation tax the ingenuity of operators—in meeting the demand for well maintenance and repair, and for the better utilization of oil and gas available in a well without the use of more material, many practices have developed that may become standard. These practices will focus attention on the adaptability of certain equipment in meeting specific conditions. The small gun-perforator used for shooting holes in tubing has been employed in the California fields and, although this equipment has been more generally adopted in other territories, its use in meeting a number of definite requirements indicates the scope of specific applications to which it is adaptable.

Gun-perforation of casing strings and of the cement that may lie behind and between strings has become standard practice both for well completion and rehabilitation work. In casing perforation the aim has been to obtain the greatest penetration possible, to make certain the bullet passes completely into the formation. In tubing perforation, however, it is frequently necessary that the bullet penetrate through the tubing only, as a hole through the casing or liner at the point where the tubing is gun-perforated may not be desirable. Bullets for the tubing gun-perforator have therefore been designed to penetrate the tubing only.

Use in Dual-Zone Wells

On the Pacific Coast every precaution is being taken during the present emergency to protect oil-well production; surface connections are therefore simplified and safeguarded to the greatest extent possible. This is done in one field where there are a number of dual-zone wells in which oil from the two zones was being produced separately (the oil from the lower zone through tubing and that from the upper zone through the casing) by combining the flow from both zones and causing all the oil to flow through the tubing. In accomplishing this objective, the tubing above the packer was gun-perforated and the oil from the upper zone allowed to enter the tubing and flow with the oil from the lower zone.

The general arrangement is shown by Fig. 1. In some wells the casing is cemented above the lower zone as shown and a liner set through that zone. In other wells a single string is set through both zones, the casing being perforated opposite each zone and cemented between. When a liner is used, a packer-type liner hanger or any other packer arrangement may have been installed, the drawing merely indicating a pack-off between zones. The casing at the surface is, of course, closed by a bradenhead or other means desired by the operator. In some cases the top of the casing is protected by cement or concrete.

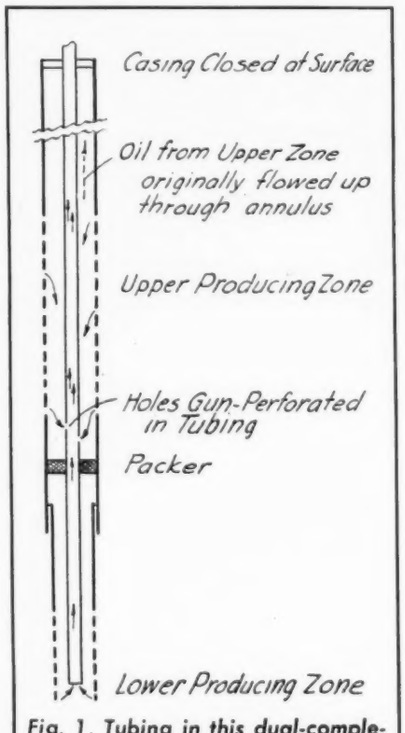

Casing Closed at Surface
Oil from Upper Zone originally flowed up through annulus
Upper Producing Zone
Holes Gun-Perforated in Tubing
Packer
Lower Producing Zone

Fig. 1. Tubing in this dual-completion well was gun-perforated to combine oil flow from the two zones

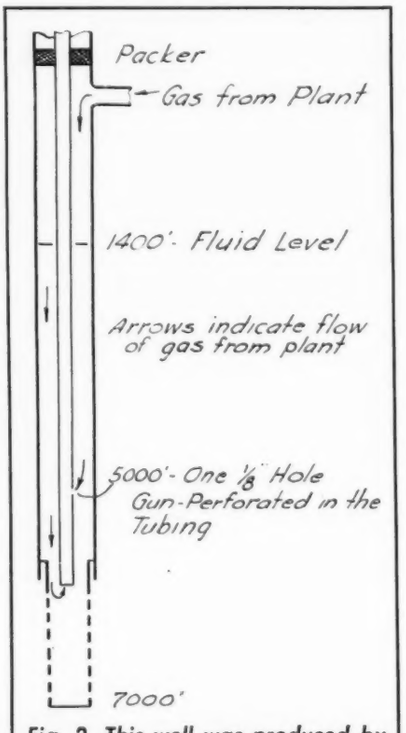


Fig. 2. This well was produced by gas-lift after tubing was gun-perforated.

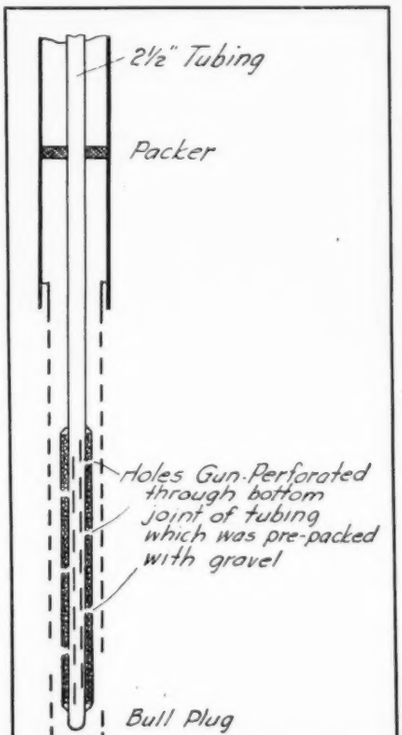
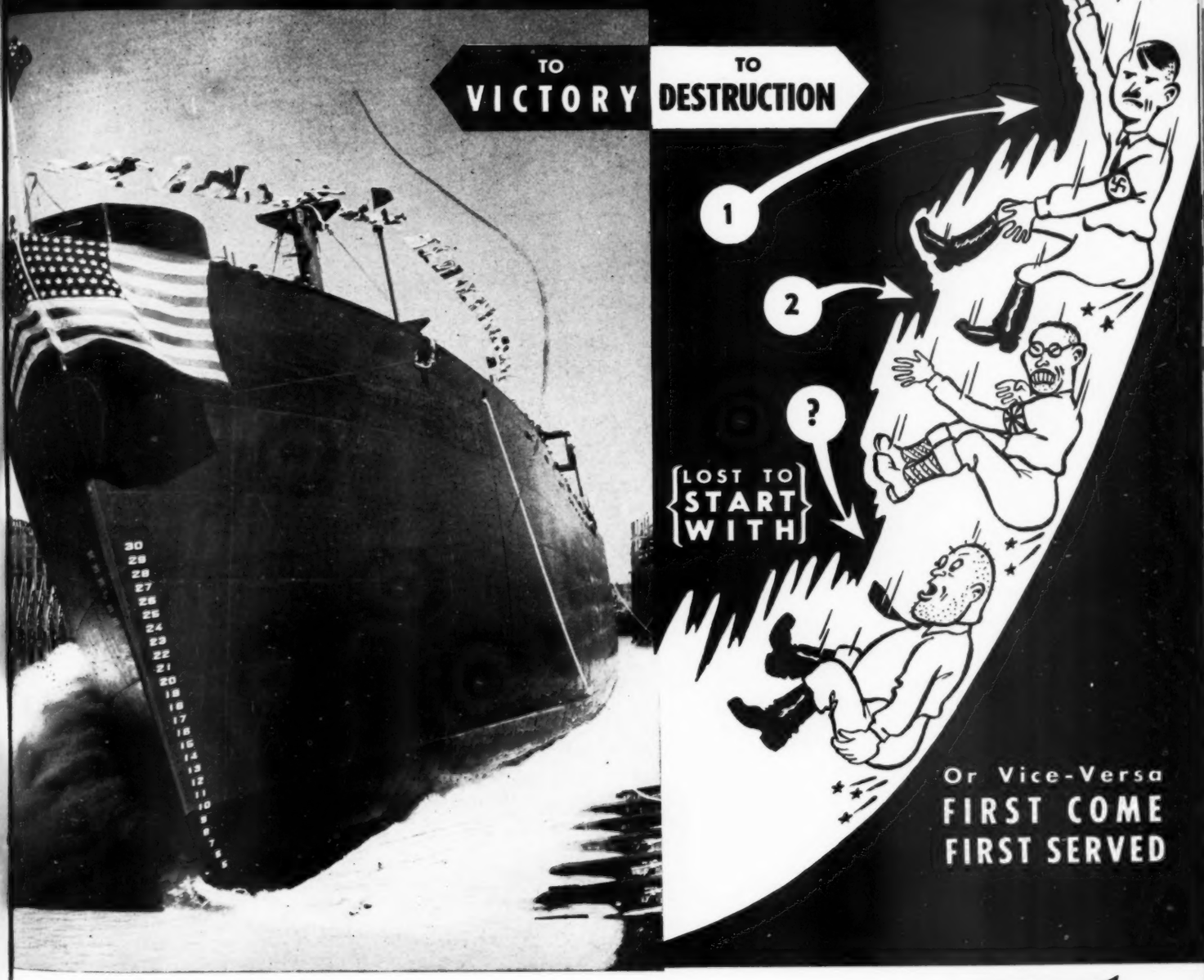


Fig. 3. A clogged gravel-pack was gun-perforated to effect oil flow

Keep 'em Sliding!

(WE'RE HELPING)



Keep the liberty ships sliding down the ways to victory. That's our first objective and by achieving it we feel that we are helping to speed up destruction of our enemy.

For many months, Oil Center has devoted a large part of its manufacturing facilities and man power to war work. That's why the O-C-T field representatives don't get around to calling on you as often as they used to. Each man has a much larger territory to "cover" now days. But after victory is won we will be back on *your* job again 100 percent. In the meantime, don't forget us!

O-C-T proudly flies this prized Treasury Flag because 100% of O-C-T employees are buying war bonds and stamps.

QUALITY O-C-T PRODUCTS

"Selling Through Leading Supply Stores"

OIL CENTER TOOL COMPANY

HOUSTON, TEXAS, U·S·A

Export Representative: Val R. Wiltich, 30 Rockefeller Plaza, New York, N. Y.

Oficina de representaciones extranjeras: Calle Lavalle 710, Buenos Aires, Argentina.

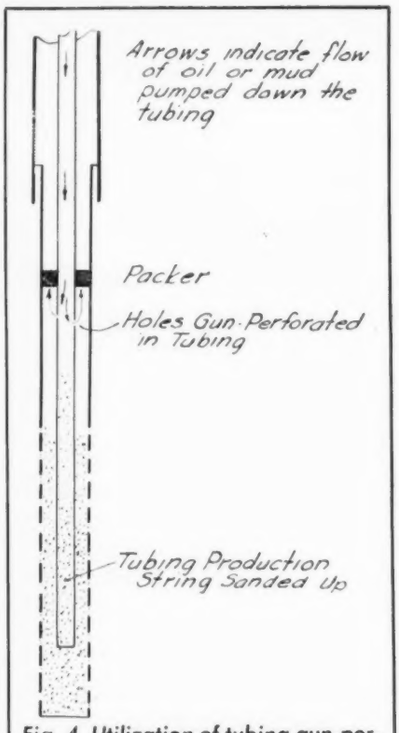

Arrows indicate flow of oil or mud pumped down the tubing
Packer
Holes Gun-Perforated in Tubing
Tubing Production String Sanded Up

Fig. 4. Utilization of tubing gun-perforator to assist in the removal of a packer

Perforating Gas-Lift Well

In one field where a number of wells are being produced by a gas-lift transmitter system, the maximum safe capacity of the plant supplying the gas is 2000 lb. per sq. in. This pressure was not sufficient to break one of the wells over. To overcome this condition, a ⅛-in. hole was gun-perforated in the tubing at approximately 5000 ft. (See Fig. 2.) The depth of the well was 7000 ft. and the fluid level 1400 ft. After the hole was shot in the tubing the well broke through at 1400 lb. per sq. in. and a continuous gas-lift operation without any major changes in the well resulted.

The admission of gas into the tubing by gun-perforating the tubing string is frequently advantageous. In one of the wells in a deep field the liner was perforated opposite several zones and tubing was set low. Gas being produced in the upper zone was needed to aid production flow, so the tubing was gun-perforated above the liner and below the packer, which was set in the casing. The perforations permitted a flow of gas into the tubing to aid in lifting the oil.

Perforating Gravel-Packed Well

The bottom joint of the tubing string of the well illustrated in Fig. 3 was pre-packed with gravel. The gravel-pack became clogged and the flow of oil through the slots was seriously impeded. Holes shot through the tubing and the gravel-pack by a gun-perforator permitted oil to flow into the tubing. Although the effect of the gravel-packing was lost, the well again produced oil. The bullets for this job were designed for greatest penetration possible and it is believed that when they passed through the gravel, the grains of the gravel bridged around the holes to permit free passageway for oil through the pack.

Removing a Packer

The utilization of the tubing gun-perforator to assist in the removal of a packer is shown in Fig. 4. The well sanded-up around and in the bottom of the tubing and the accumulation prevented movement of the packer. Holes were gun-perforated below the packer and fluid was forced down the tubing and out the holes. (The fluid for such an operation can be either mud or oil, according to the conditions.) The fluid under pressure provided a hydraulic lifting force below the packer and aided in moving it upward.

A packer made immovable by deposition of sand, mud, and other foreign matter is illustrated by Fig. 5. In this well, holes were shot in the tubing just above the packer with a tubing gun-perforator and the material on top of the packer then washed out. Frequently in cases of this kind the packer is a full string; but when a liner is in the well it is sometimes set with a packer liner hanger or with some other packer arrangement. The packer shown in the drawing is merely indicative of a packer set above the perforated section of the casing or liner.

Removing Stuck Drill Pipe

The use of the small gun-perforator for removal of stuck drill pipe has become quite prevalent. In general, when the drill pipe is stuck and circulation cannot be recovered, the gun is run to the lowest depth possible and there the pipe is shot to obtain circulation. If circulation is not then obtained holes are shot progressively higher in the string until circulation results. It is frequently possible to regain circulation through large sections of silt, mud, and sand by use of the perforator.

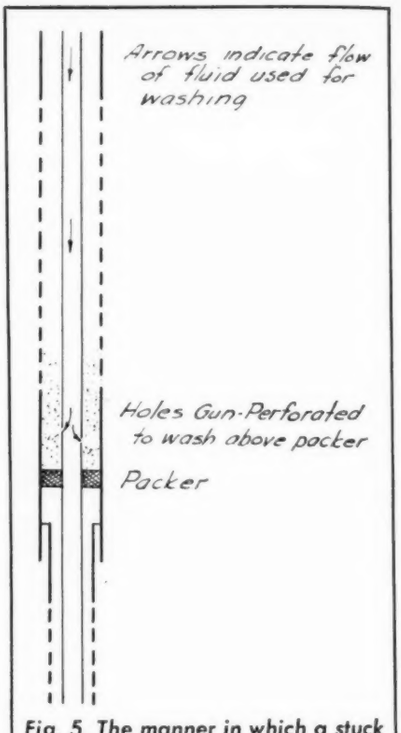


Fig. 5. The manner in which a stuck packer was removed with the aid of a tubing gun-perforator

☆ ☆ ☆

New Price Structure Established For Industrial Fuel Oils

A new price structure and a new schedule of dollar and cents ceilings for industrial fuel oils refined in parts of Kansas, Arkansas, Louisiana, Oklahoma, New Mexico, and Texas has been announced by the Office of Price Administration.

The new schedule was devised by OPA and the office of the Petroleum Administrator for War for the following purposes:

1. To make more industrial fuel oil available in the areas involved by encouraging the blending of low gravity and the cheaper residual oils with the higher gravity, more costly distillate fuels.

2. To equalize prices in the several market areas involved by establishing specific prices f. o. b. refineries on a gravity basis (American Petroleum Institute scale) rather than on a basis of standard commercial specifications for Nos. 5 and 6 fuel oils as in the past.

3. To meet increasing wartime demands of railroads and industries in the areas involved by augmenting local supplies and eliminating uneconomic transportation of fuel oils from the Gulf Coast ports, which has become a costly practice under previously prevailing price schedules.

4. To release a substantial number of oil tank cars now used for transporting fuel oil from the Gulf Coast to inland points. These cars will be made available to haul fuel to domestic and industrial consumers in the eastern states.

crease of 400,000 Bbl. in
aily Demand Seen in 1943
Your National Ideal Equipment will Handle the job
We asked our Field Engineers:
"WHAT CAN OUR CUSTOMERS DO TO PROLONG THE LIFE OF THEIR NATIONAL SUCKER RODS?"
SPENSABLE to Victory...
EVEN THE CUSTOMARY LONG
SERVICE OF IDEAL CHAIN CAN BE EXTENDED
A LITTLE EXTRA SERVICE FROM
CARE WILL GIVE YOU A LOT OF EXTRA YOUR IDEAL Power Pumps
EQUIPMENT MAINTENANCE ASSURES PRODUCTION...
THE MAN-MADE
A LOT OF EXTRA SERVICE FROM YOUR IDEAL Power Pumps
THE NATIONAL SUPPLY COMPANY
From OIL & GAS JOURNAL
ber 10, 1942

The information contained in our 1942 advertising on the proper care and maintenance of National-Ideal Machinery and Equipment has been reproduced in two convenient forms; one on cardboard for posting at point of field operations and the other in a folder for office reference files.

In view of the contemplated demands for increased petroleum production during 1943, we urge you to write us for sufficient quantities of both types of these forms for distribution throughout your organization.

You will find this information most helpful in maintaining the efficiency and prolonging the life of your present equipment during the War period.

NSCO

THE NATIONAL SUPPLY COMPANY

Executive Offices: Pittsburgh, Penna. • General Sales Office: Toledo, Ohio • Division Offices: Fort Worth, Texas; Tulsa, Okla.; Torrance, Calif. EXPORT: The National Supply Corporation, 30 Rockefeller Plaza, New York, N. Y., U. S. A.; River Plate House, 12 South Place, London, E. C. 2, *Limited Liability.*

Vapor-Pressure Chart For Volatile Hydrocarbons*

☆ Published data plotted on chart in commonly-used units of pressure and temperature to facilitate use in laboratory

by R. Vincent Smith

Assistant Chemical Engineer, U. S. Bureau of Mines, Bartlesville, Oklahoma

WHILE studying the physical properties of petroleums and natural gases, particularly the fractional distillation of petroleum oils and natural gases in the laboratories of the U. S. Bureau of Mines, Bartlesville, Oklahoma, the writer frequently had to refer to published data on the vapor pressures of volatile hydrocarbons. As such data are scattered widely throughout the literature, often not readily available, and frequently referred to uncommon units of pressure and temperature, an attempt was made to collect them, refer them to commonly-used units of pressure and temperature, and arrange them on a chart that could be used conveniently in the laboratory.‡ The ranges of pressures and temperatures are those commonly used in studies requiring data on vapor pressures and boiling points of hydrocarbons from methane to n-dodecane.

In constructing the chart, many data were taken from already compiled sources,[19, 21, 23, 24, 25, 28, 36, 43, 44] but wherever possible the data were compared and checked with the original before they were used to interpolate and extrapolate the vapor-pressure curves.

R. VINCENT SMITH

was born March 27, 1913, at Bynumville, Missouri—Graduated from University of Missouri with A.B. degree in 1934, and received an A.M. degree from same institution in 1935, majoring in physical chemistry—Was graduate assistant in chemistry one year at the Missouri School of Mines—Employed by Petroleum and Natural Gas Division of the U. S. Bureau of Mines, Bartlesville, Oklahoma, 1936, and is now assistant chemical engineer—His work has been in petroleum production research—Is a member of Sigma Xi and the American Chemical Society.

Discussion of Vapor Pressure

When the vapor of a single component liquid is exposed to "free" space above it there is a continuous movement of the molecules of the liquid from the surface of the liquid into the "free" space, and at the same time a continuous passing of molecules of the vapor into the liquid. If these two phenomena exactly balance one another, the liquid and its vapor will be in equilibrium, and the vapor will be saturated with liquid. The resultant pressure exerted by the saturated vapor is known as its vapor pressure.

Vapor pressures of single component liquids are independent of the quantities of vapor or liquid in equilibrium but vary with temperature, and for every temperature below the critical pressure a definite pressure is exerted by a vapor in equilibrium with liquid.

Many vapor-pressure charts have as their basis the coördinates (logarithm of vapor pressure and reciprocal of absolute temperature) suggested by an integrated form of the Clausius-Clapeyron equation,† which is as follows:

$$\log p = -\frac{A}{T} + B,$$

Where:

p = vapor pressure,

T = absolute temperature, and

A and B = constants.

Experimental data, however, do not yield straight lines when plotted upon this basis but yield curves in which the curvature is small throughout their extent. Consequently, the logarithm of pressure and the reciprocal of absolute temperature were chosen as coördinates for a convenient graphic means for presenting data on vapor pressures of hydrocarbons.

A vapor-pressure chart using a special nonuniform temperature scale has been suggested by Cox[16] in an effort to present vapor-pressure data as straight lines. The coördinates of the chart are the logarithm of vapor pressure and a temperature scale obtained by drawing a straight line on semilogarithmic paper and allowing the line to be the vapor-pressure curve of some substance whose vapor pressures are known accurately. The temperature scale is determined by using the logarithm of the pressure to determine corresponding temperature points.

Description of Chart

In the construction of the vapor-pressure chart, collected data were plotted on semilogarithmic coördinate paper, on which the ordinate is the logarithm of vapor pressure and the abscissa is the reciprocal of degrees Kelvin (degrees centigrade absolute). As finally drawn, the vertical lines in the body of the chart represent degrees centigrade, and for extra convenience a Fahrenheit-temperature scale has been placed at the top of the chart. To facilitate use of the chart in low-temperature distillation analyses, a millivolt scale has been provided for users of

*Reprinted from U. S. Bureau of Mines Information Circular 7215.

‡A copy of the writer's chart is shown as P 210.0, P 771.0 in the Continuous Tables Section of the January, 1943, issue of *The Petroleum Engineer*.

†A derivation of the equation is given by Getman and Daniels.[22]

YOUR CORROSION PROBLEM CHANGED WITH PEARL HARBOR

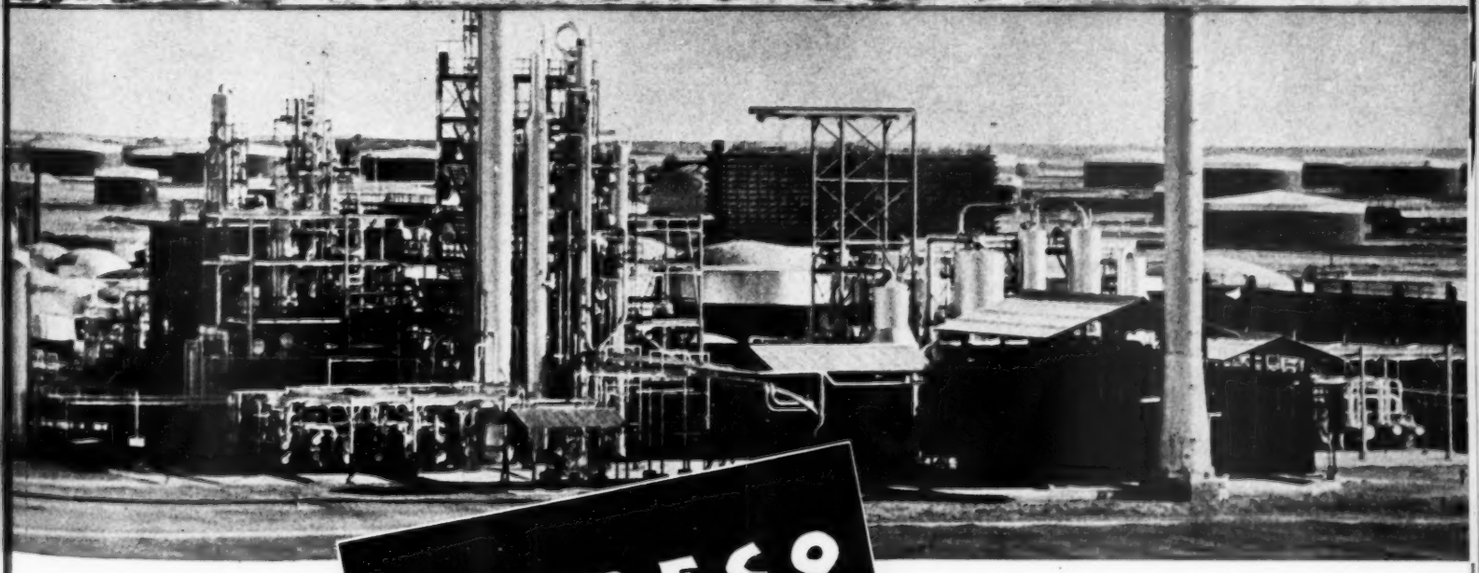
...because the Pearl Harbor attack launched America on its drive to victory... and that drive to ultimate victory changed "business as usual."

In refineries, in spite of the vital war job they are doing, the scarcity of corrosion-resistant alloy metals is bound to affect heat exchanger maintenance.

Salty crudes are a recognized ...rosion and plugging in ...gers. Salt hazards not ... exchanger tube life ... necessary replace- ... lead to inferior ... and ...rded throughput

... salt ... pro- ...ally, with the ... metals in ...bility of ... on fre-

OFFICIAL U. S. NAVY PHOTO — PEARL HARBOR SCENE



PETRECO

DESALTING DEHYDRATING

PETROLEUM RECTIFYING COMPANY OF CALIFORNIA

5121 SOUTH WAYSIDE DRIVE, HOUSTON, TEXAS
EDISON BUILDING, TOLEDO, OHIO
530 WEST SIXTH ST., LOS ANGELES, CALIFORNIA
Representatives in all principal fields and refining centers.

3-element copper-constantan thermocouples. The data required to construct the temperature scale, labeled "millivolts for 3-element copper-constantan thermocouple," were taken from the International Critical Tables.[25] Although the values taken from the tables are arbitrary, matched couple pairs may be obtained that will permit using the supplemental scale. For precise work, each individual thermocouple should be calibrated to determine individual deviations from this scale.

The pressure and temperature ranges covered by the chart provide space for plotting the vapor pressure of all the hydrocarbons up to n-dodecane (n-$C_{12}H_{26}$), with the exception of pressures for methane below 15 mm. of mercury. The inset at the upper right of the chart has an expanded temperature scale, so that the isomers of hexane and heptane could be shown more clearly than on the main chart. Available data for the isomers of hexane and heptane are relatively incomplete, and only the normal boiling-point data were found in the literature. Accordingly, dashed curves are used where data were extrapolated.

Numerous equations for calculating vapor pressures were found in the literature, and in general the equations yielded results that agreed with the experimental data over narrow ranges of pressure; over more extensive pressure ranges the results seldom agreed with the experimentally determined data, and for that reason vapor pressures calculated by means of equations were not used in constructing the chart.

Each averaging curve on the chart was drawn so that its shape was similar to that of the adjacent curves. Normal boiling-point data given by Egloff,[21] which are weighted averages of all available experimental data, were given the most consideration in determining the position of the curves. Many of the data for pressures above 1000 mm. of mercury were taken from Tables annuelles de constantes et donnees numeriques[44] and from the work by Young,[48] who published the original data in connection with a study of the boiling points of the normal paraffin hydrocarbons. The close agreement between these and other data in the low-pressure range and data at higher pressures from other sources indicated that considerable weight could be given those data in determining the position of the averaging curves at high pressures.

The data available for determining the greater part of curves for methane,[1, 19, 21, 24, 28, 36, 44, 48] ethylene,[12, 14, 19, 21, 24, 27, 28, 32, 33, 36, 44] and ethane[1, 6, 10, 12, 14, 19, 21, 23, 24, 26, 28, 31, 32, 33, 35, 36, 37, 44, 48] were in close agreement. It was necessary, however, to extend the curves to low pressures, and the extrapolations (dashed part of the curves) were drawn to conform in shape with the adjacent curves.

There was good agreement among the published data for propylene (propene)[13, 14, 19, 21, 24, 27, 28, 33, 36, 38, 45] from different sources for pressures above 1000 mm. of mercury, and the curve for propylene was drawn parallel to the curve for propane, even though the curve did not pass through all data points in the low-pressure range. Published data for propane[1, 8, 13, 14, 17, 19, 21, 23, 24, 28, 33, 36, 44, 48] do not agree exactly, and small differences were noted in the pressure range below 1000 mm. of mercury. The trend of the data, however, was consistent, and it was possible to draw a curve for propane with its position fixed within the limit of probable experimental errors.

The available data for *iso*butane (methyl-propane)[2, 14, 15, 17, 19, 21, 23, 24, 28, 36, 38] between mercury pressures of 300 and 760 mm. were inconsistent in trend but regular at higher and lower pressures. Consequently, the averaging curve was drawn giving the least weight to data in the intermediate pressure range.

Two distinct curves for pressures greater than 1000 mm. of mercury were obtained when the data for n-butane[1, 4, 9, 13, 14, 15, 17, 19, 21, 23, 24, 28, 36, 38, 44, 48] were plotted. As the curve determined by the data reported by Young[48] conformed to data from other sources in the low-pressure range, the curve shown on the chart was drawn through one set of data without giving consideration to the other set.

The available vapor-pressure data for neopentane (2,2-dimethylpropane)[3, 19, 21, 43, 46] are complete only in the pressure range from 100 to 1000 mm. of mercury, and although there are small differences between the values from the five sources, they are small and of the magnitude of experimental errors. The neopentane curve was extrapolated in both directions so as to correspond in shape with adjacent curves for n-butane and *iso*pentane. The values of the critical constants for neopentane reported by Doss[19] and originally published by the Standard Alcohol Company[43] are close to those of *iso*pentane. Consequently, they do not conform to the trend of the vapor-pressure data, and it was concluded that an error exists either in the vapor-pressure data or in the critical-pressure and temperature data, or in both. As the vapor-pressure data for neopentane are from two sources that are in agreement, more confidence can be placed in the vapor-pressure data than in the reported critical-pressure and temperature data.

Published data for *iso*pentane,[19, 21, 24, 28] n-pentane,[1, 19, 21, 24, 28, 39, 44, 47, 48] n-hexane,[1, 19, 21, 24, 28, 29, 39, 42, 44, 47, 48] n-heptane,[1, 7, 11, 19, 20, 21, 24, 26, 28, 29, 34, 39, 41, 42, 44, 47, 48] and n-octane[1, 19, 21, 24, 28, 29, 30, 39, 44, 47, 48] agree and permit determining the positions of the averaging curves with little doubt regarding their correct position on the chart.

Most of the available data for n-nonane, n-decane, n-undecane, and n-dodecane were published by Young[48] and curves drawn through the plotted data are regular, consistent in trend, and agree with those based on data from other sources—n-nonane,[1, 19, 21, 39, 44, 47, 48] n-decane,[1, 19, 21, 28, 30, 39, 44, 47, 48] n-undecane[1, 19, 21, 39, 44, 47, 48] and n-dodecane.[5, 19, 21, 39, 44, 47, 48]

The data on critical pressures and temperatures compiled by Doss[19] and Pickering[36] were used in the work reported here, as they were consistent with other data except for those given for 2,2-dimethylpropane (tetramethylmethane or neopentane) and n-decane.

The inset at the upper right of the chart is a plot of the available data for the insomers of hexane[11, 19, 21, 24, 28] and heptane.[11, 19, 20, 21, 40] Data for 2,2-dimethylbutane,[11, 19, 21, 24, 28] 2-3-dimethylbutane,[11, 19, 21] 2,2,3-trimethylbutane,[11, 19, 20, 21, 40] and 3-ethylpentane[11, 19, 20, 21] are complete between pressures of 100 and 1000 mm. of mercury but incomplete for the other isomers. Certain curves, therefore, have been indicated on the chart by dashed lines approximately parallel to the curves for closely related components on which complete data were available.

Conclusion

The vapor-pressure chart of many volatile, naturally occurring hydrocarbons was prepared from data gleaned from a long list of references. The search of the literature revealed that vapor-pressure data are complete for the normal hydrocarbons up to and including n-decane (n-$C_{10}H_{22}$), with the exception of n-nonane (n-C_9H_{20}). Vapor-pressure data are incomplete for *iso*pentane below pressures of 50 mm. of mercury. The available critical constants for neopentane are apparently in error, and the vapor-pressure data, when plotted on the chart, yield 2 lines with slightly different slopes. Data for *iso*butane are inconsistent in trend between pressures of 300 and 760 mm. of mercury.

Need exists for a set of empirical equations that have been fitted to experimental data and that would permit accurate calculation of vapor-pressure

Here's a **NEW BULLETIN** *you should have for reference..*

DESCRIBES 3 ENTIRELY NEW, HIGH-EFFICIENCY MODELS OF FLUOR GAS CLEANERS FOR THE REMOVAL OF ENTRAINED LIQUIDS & SOLIDS FROM GAS STREAMS

Now, from Fluor, comes an entirely new, complete High-efficiency line of Gas Cleaners for the removal of entrained liquids and solids from gas and other vapor streams. Three models — the Vertical Liquid Removal type, the Vertical Solids Removal type and the Horizontal Liquid Removal type — are now available, designed and built for a wide range of operating pressures and capacities.

These new Fluor Gas Cleaners are completely described and illustrated in detail in a new Bulletin now ready for distribution. *This is a Bulletin you should possess.* In it the principles of design, the method of operation, construction details and materials are comprehensively outlined. The separator element — the heart of the new Fluor Gas Cleaner — receives particular emphasis because of its importance.

The effectiveness of the principle of the new Fluor Gas Cleaners is proved by recent installations, as replacements for other types. In these installations liquid carryover, previously measured in many gallons per million cubic feet, were reduced to negligible quantities too small to measure.

You should have a copy of this new Bulletin, titled "Fluor Gas Cleaners," to read and keep for reference. Write today for your copy.

FLUOR GAS CLEANERS

SINCE 1890

THE FLUOR CORPORATION LTD.
2500 SO. ATLANTIC BLVD., LOS ANGELES, CALIF.
NEW YORK • PITTSBURGH • KANSAS CITY • HOUSTON

extrapolations and interpolations over the entire range of pressures. Such a set of equations would "round out" present knowledge of vapor pressures of hydrocarbons.

The vapor-pressure chart has been useful in distillation procedures where pressures and temperatures vary over wide ranges. The chart has been used successfully to determine "cut points" for distillations at pressures above atmospheric and for distillations at pressures below 50 mm. of mercury.

Acknowledgments

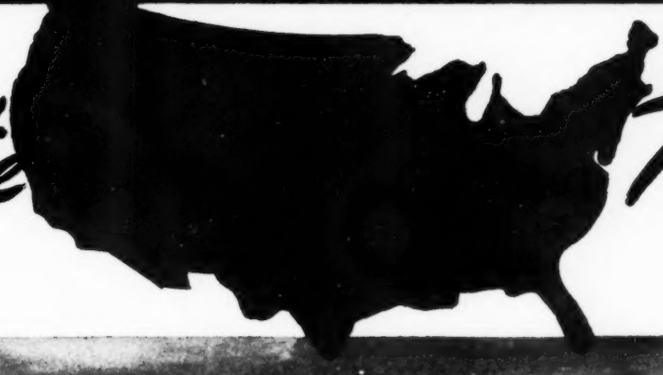
The investigation reported here was made under the general supervision of R. A. Cattell, chief engineer, Petroleum and Natural Gas Division, U. S. Bureau of Mines, Washington, D. C., and N. A. C. Smith, supervising engineer, Petroleum Experiment Station, Bartlesville, Oklahoma. The work was carried out under the direct supervision of Kenneth Eilerts, physical chemist, and R. E. Heithecker, senior petroleum engineer, Bureau of Mines, Bartlesville.

The vapor-pressure chart was prepared by S. B. Thomas. The manuscript was read and criticised by the following members of the Bureau of Mines: E. S. Burnett, C. B. Carpenter, Kenneth Eilerts, H. C. Miller, M. A. Schellhardt, and Gustav Wade. To them the writer is deeply indebted.

Bibliography

1. "Gasoline from Natural Gas. I. Method of Removal," by R. P. Anderson, *Ind. Eng. Chem.*, Vol. 12, June, 1920, p. 548.
2. "The Heat Capacity and Entropy, Heats of Fusion and Vaporization, and the Vapor Pressure of Isobutane," by J. G. Aston, R. M. Kennedy and S. C. Schumann. *Jour. Am. Chem. Soc.*, Vol. 62, August, 1940, p. 2061.
3. "Heat Capacities and Entropies of Organic Compounds. II. Thermal and Vapor-Pressure Data for Tetramethylmethane from 13.22°K. to the Boiling Point. The Entropy from its Raman Spectum," by J. G. Aston and G. H. Messerly. *Jour. Am. Chem. Soc.*, Vol. 58, December 1936, p. 2358.
4. "The Heat Capacity and Entropy, Heats of Fusion and Vaporization, and the Vapor Pressure of n-Butane," by J. G. Aston and G. H. Messerly. *Jour. Am. Chem. Soc.*, Vol. 62, August, 1940, p. 1918.
5. "A Wide-Range Boiling-Point Conversion Chart for Hydrocarbons and Petroleum Products," by E. S. Beale and P. Docksey. *Jour. Inst. Petrol. Technol.*, Vol. 21, 1935, p. 866.
6. "The Compressibility of and an Equation of State for Gaseous Ethane," by J. A. Beattie, Canfield Hadlock, and Noland Poffenberger. *Jour. Chem. Phys.*, Vol. 3, February, 1935, p. 95.
7. "The Normal Boiling Point and Critical Constants of Normal Heptane," by J. A. Beattie and W. C. Kay. *Jour. Am. Chem. Soc.*, Vol. 59, September, 1937, pp. 1586-1587.
8. "The Critical Constants of Propane," by J. A. Beattie, Noland Poffenberger, and Canfield Hadlock. *Jour. Chem. Phys.*, Vol. 3, February, 1935, pp. 96-97.
9. "The Vapor Pressure and Critical Constants of Normal Butane," by J. A. Beattie, G. L. Simard, and Gouq-Jen Su. *Jour. Am. Chem. Soc.*, Vol. 61, January 1939, pp. 25-26.
10. "The Critical Constants of Ethane," by J. A. Beattie, Gouq-Jen Su, and G. L. Simard. *Jour. Am. Chem. Soc.*, Vol. 61, April, 1939, pp. 924-925.
11. "Physical Properties of Some Purified Aliphatic Hydrocarbons," by D. B. Brooks, F. L. Howard, and H. C. Crafton, Jr. *Nat. Bureau of Standards Jour. Research*, Vol. 24, January, 1940, pp 43-44.
12. "The Vapor Pressure of Ethane and Ethylene at Temperatures Below Their Normal Boiling Points," by G. A. Burrell and I. W. Robertson. *Jour. Am. Chem. Soc.*, Vol. 37, August, 1915, p. 1899.
13. "The Vapor Pressures of Propane, Propylene and Normal Butane at Low Temperatures," by G. A. Burrell and I. W. Robertson. *Jour. Am. Chem. Soc.*, Vol. 37, September, 1915, pp. 2191-2192.
14. "Vapor Pressures of Various Compounds at Low Temperatures," by G. A. Burrell and I. W. Robertson. *Bureau of Mines Tech. Paper 142*, 1916, 32 pp.
15. "The Preparation and Physical Properties of Alpha, Beta, and Gamma Butylene and Normal and Isobutane," by C. C. Coffin and O. Maas. *Jour. Am. Chem. Soc.*, Vol. 50, May, 1928, p. 1433.
16. "Pressure-Temperature Chart for Hydrocarbon Vapors," by E. R. Cox. *Ind. Eng. Chem.*, Vol. 15, June, 1923, pp. 592-593.
17. "Thermodynamic Properties of Butane, Isobutane, and Propane," by L. I. Dana, A. C. Jenkins, J. N. Burdick, and R. C. Timm. *Refrig. Eng.*, Vol. 12, June, 1926, pp. 387-405.
18. "P-V-T Relations for Propane," by W. W. Deschner and G. G. Brown. *Ind. Eng. Chem.*, Vol. 32, June, 1940, p. 837.
19. *Physical Constants of the Principal Hydrocarbons*, by M. P. Doss. New York, 2d ed., 1939, pp. 1-7.
20. "The Preparation and Properties of the Isomeric Heptanes. Part I. Preparation," by Graham Edgar, George Calingaert and R. E. Marker. *Jour. Am. Chem. Soc.*, Vol. 51, May, 1929, p. 1488.
21. *Physical Constants of Hydrocarbons*, by Gustav Egloff. New York, Vol. 1, 1939, pp. 1-81.
22. *Outlines of Theoretical Chemistry*, by F. H. Getman and Farrington Daniels. New York, 6th ed., 1937, pp. 126-129.
23. *Handbook of Butane-Propane Gases*. Los Angeles, 2d ed., 1935, p. 8.
24. *International Critical Tables*. New York, Vol. 3, 1928, pp. 216-245.
25. *International Critical Tables*. New York, Vol. 1, 1928, p. 58.
26. "Liquid-Vapor Phase Equilibrium Relations in the Ethane-n-Heptane System, by W. B. Kay. *Ind. Eng. Chem.*, Vol. 30, April, 1938, pp. 461-463.
27. "The Vapor Pressures of Certain Unsaturated Hydrocarbons," by A. B. Lamb and E. E. Roper. *Jour. Am. Chem. Soc.*, Vol. 62, April, 1940, p. 809.
28. *Physicalisch-chemische Tabellen*, by Landolt-Bornstein-Roth und Scheel. Berlin, Vol. 2, 1923, pp. 1354-1357.
29. "Vapor Pressure of Organic Solutions," by E. H. Leslie and A. R. Carr. *Ind. Eng. Chem.*, Vol. 17, August, 1925, p. 814.
30. "Vapor Pressures of Some Hydrocarbons," by E. G. Linder. *Jour. Phys. Chem.*, Vol. 35, February, 1931, pp. 531-535.
31. "The Vapor Pressure of Ethane Near the Normal Boiling Point," by A. G. Loomis and J. E. Walters. *Jour. Am. Chem. Soc.*, Vol. 48, August, 1926, pp. 2053-2054.
32. "Some Physical Properties of Ethane, Ethylene and Acetylene," by O. Maas and D. McIntosh. *Jour. Am. Chem. Soc.*, Vol. 36, April, 1914, p. 740.
33. "Some Physical Properties of Hydrocarbons Containing Two and Three Carbon Atoms," by O. Maas and C. H. Wright. *Jour. Am. Chem. Soc.*, Vol. 43, May, 1921, p. 1102.
34. "The Accurate Measurement of Heats of Vaporization of Liquids," by J. H. Matthews. *Jour. Am. Chem. Soc.*, Vol. 48, March, 1926, p. 575.
35. "An Azeotropic Mixture of Acetylene and Ethane at Atmospheric Pressure," by W. A. McMillan. *Jour. Am. Chem. Soc.*, Vol. 58, August, 1936, p. 1345.
36. "A Review of the Literature Relating to the Critical Constants of Various Gases," by S. F. Pickering. *Nat. Bur. of Standards Scientific Papers*, Vol. 21, S541, 1926-27, p. 629.
37. "The Vapor Pressures and Specific Volumes of the Saturated Vapor of Ethane," by Frank Porter. *Jour. Am. Chem. Soc.*, Vol. 48, August, 1926, p. 2058.
38. "The Critical Constants of Normal Butane, Iso-Butane, and Propylene and Their Vapor Pressures at Temperatures Between 0°C. and 120°C.," by F. M. Seibert and G. A. Burrell. *Jour. Am. Chem. Soc.*, Vol. 37, December, 1915, p. 2691.
39. "Physical Properties of the Normal Paraffin Hydrocarbons, Pentane to Decane," by A. F. Shepard, A. L. Henne, and T. Midgley, Jr. *Jour. Am. Chem. Soc.*, Vol. 53, May, 1931, p. 1951.
40. "Boiling Points of Benzene, 2,2,3-Trimethylbutane, 3-Ethylpentane, and 2,2,4,4-Tetramethylpentane Within the Range 100 to 1500 Millimeters of Mercury," by E. R. Smith. *Nat. Bureau of Standards Jour. Research*, Vol. 26, February, 1941, p. 134.
41. "Boiling Points of n-Heptane and 2,2,4-Trimethylpentane Over the Range 100 to 1500 Millimeter Pressure," by E. R. Smith. *Nat. Bureau of Standards Jour. Research*, Vol. 24, March, 1940, pp. 233-234.
42. "Molecular Orientation and the Partial Vapor Pressures of Binary Mixtures. I. Systems Composed of Normal Liquids," by C. P. Smyth and E. W. Engel. *Jour. Am. Chem. Soc.*, Vol. 51, September, 1929, p. 2649.
43. "Properties of Hydrocarbon Gases." Standard Alcohol Company, November, 1937.
44. *Tables Annuelles de Constantes et Donnees Numeriques*, 1927-28. Paris, Vol. 8, 1931, pp. 249-250.
45. "P-V-T Relations of Propylene," by W. E. Vaughn and N. R. Graves. *Ind. Eng. Chem.*, Vol. 32, September, 1940, p. 1254.
46. "Preparation of Tetramethylmethane (Neopentane) and Determination of Its Physical Constants," by F. C. Whitmore and G. H. Fleming. *Jour. Am. Chem. Soc.*, Vol. 55, September, 1933, p. 3806.
47. "The Physical Properties of the Paraffin Hydrocarbons," by R. E. Wilson and W. H. Bahlke. *Ind. Eng. Chem.*, Vol. 16, February, 1924, p. 119.
48. "On the Boiling Points of the Normal Paraffins at Different Pressures," by Sidney Young. *Proc. Roy. Irish Acad., Section B*, April, 1928, pp. 65-92.

——— ☆ ☆ ☆ ———

From the  *Pacific...*

. wherever there's production, the reputation of Tret-O-lite is tablished. In the Eastern and Great Lakes areas, in the Mid-ontinent and Gulf Coast, in the Rocky Mountain and Pacific opes, from Canada to South America, Tret-O-lite's leadership recognized. The Tretolite Company offers compounds devel-ped to treat properly the many different crudes produced. Like-ise it provides a field service designed to give effective assistance on dehydrating problems everywhere. This backing of manu-facture and service with intensive research is only one of the reasons for Tret-O-lite leadership. For your dehydrating needs, get the best . . . get Tret-O-lite.

TRETOLITE COMPANY
Manufacturing Chemists
WEBSTER GROVES, ST. LOUIS COUNTY, MO. • LOS ANGELES, CALIF.

Complete Service for Every Field

Oil is Ammunition • Treat it Right

Tret-O-lite

REG. U.S. PAT. OFF.

DEHYDRATING **DESALTING**

PETROLEUM ENGINEER Exclusive Feature

Refinery Practice for the Operating Man

Vocational Class Proceedings in Refinery Engineering

Manufacture of Lubricating Oils

Class Meeting No. 6 (continued)

NOTE: Throughout the class proceedings, no attempt is made to distinguish the identity of the pupil speaking. When a series of remarks is made by pupils it usually denotes an interchange of discussion among the class members themselves.

Pupil: What is done with the ketone?

Pupil: Nothing is mentioned about its use; you get a condensate mixture of acetone and water. That mixture is probably suitable for extraction.

Pupil: The author of the text states that charging stocks from crudes ranging from 40 viscosity at 210°F. to 160 viscosity at 210°F. are suitable.

Pupil: Yes, even as high as 185 viscosity at 210°F.

Pupil: The percentage of solvents used would vary according to the charging stock, I believe. For average operation, ketone percentage will range from 25 to 40 percent toluene and 40 to 50 percent benzol.

Pupil: What is done with the wax?

Pupil: Most of it goes to cracking stock. I believe it is possible that wax material can be obtained by propane filtration.

Pupil: Is pre-treatment necessary?

Pupil: No.

Leader: Where the charging stock is low enough in viscosity so that wax would be in the commercial melting point range they do get a nice cut of wax on it.

Pupil: Isn't it necessary to bring this material up to the temperature where there will be complete solution on the waxy material?

Leader: Yes, at the beginning.

Pupil: How much—just ordinary?

Leader: Ordinary atmospheric temperatures. To have better filtering rates it is best to have something above 100°F.

Pupil: How is this temperature generally maintained?

Leader: By refrigeration; usually by the use of ammonia.

Pupil: Acetone and benzol are sometimes used.

Leader: The same essential unit is used.

Pupil: You would not want any C_4 in there if you had to separate it from the acetone and benzol.

Leader: That is correct. Now we will review the common terms "naphthenic" and "paraffinic."

Pupil: Reference is made to the two stages. The closer it becomes to paraffinic, the more useful it is as motor oil. The naphthenic is for refinery use.

Leader: On any certain crude?

Pupil: Gulf Coast crude.

Leader: When extractions are made, they are somewhat like Gulf Coast oils. The word "paraffin" is a matter of terminology and is in general use.

Pupil: You mean there's no connection between names and chemical formulas?

Leader: It's a matter of general use. What would you consider the merits of these extracts? Are they olefinic?

Pupil: Aromatic.

Leader: This is mentioned on page 110 at the bottom of the page. Indications are that these are of the aromatic type. What happens with subsequent extractions? What happens with regard to gravity of extracts from aromatics as you increase removal of the extract? As you increase this removal of extract how will the curve progress?

Pupil: Upward.

Leader: Does that tell the story? It will give some idea to say that, as more and more extract is removed, we will be getting the kind of oil desired, but at increased costs.

Pupil: I believe we were led to believe that minus 10 pour-point oil with naphthenic and paraffinic characteristics would be better than zero pour-point oil. Will the oil removed bring the pour point down to zero or minus 10 on oils more paraffinic in nature? Probably you are lowering the quality of the oil rather than raising it.

Leader: I think that is possible.

Pupil: That all depends on what you are looking for.

Leader: Say, lubricating oils?

Pupil: 20° pour point.

Leader: That would depend also upon the use of pour-point depressants. I am wondering if you are getting confused on the use of the terms "paraffinic" and "naphthenic."

Pupil: The term "paraffin base" attached to oil does not have any relationship to paraffin wax, does it?

Leader: Not as we think of it.

Pupil: When removing wax are we removing paraffin oils?

Leader: Yes, but perhaps we should wait until we study pour-point depressants. We are getting confused on that, too, but I believe most of you think that if we dewax and remove pour-point material we may be getting into oils we wish to retain.

Pupil: Are paraffinic hydrocarbons waxy?

Leader: Many of them.

Pupil: I read an article in which the statement was made that when you get down to the last one-third of the charging stock, by comparison it was determined that last one-third was naphthenic. Evidently all paraffinics had been removed by that time.

Pupil: Paraffin waxes are poor lubricants; but lubricating oils may be paraffinic.

Pupil: Do Oklahoma crudes yield high pour-point oils?

Leader: We will bring this out when

TABLE 5

Difference between selectivity and solvent power

Solvent, percent by volume	Temperature of extraction, °F.	Raffinate	
		Yield, percent	Viscosity index
100 percent aniline	75	88	35
50 percent nitrobenzene	35	78	35
200 percent aniline	75	85	39
45 percent nitrobenzene	35	85	33
100 percent aniline	75	88	35
100 percent nitrobenzene	35	66	47

This table appears as Table 26 on page 117 of Modern Methods of Refining Lubricating Oils, by Vladimir A. Kalichevsky.

NO. 2 OF A SERIES

HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

The FIRST WELDING FITTINGS 1ST AND STILL THE BEST

Two ways that Tube-Turn welding fittings avoid wasting men and hours in war plants!

1 SPEED-UP PIPING INSTALLATION

2 GREATLY REDUCE MAINTENANCE

ester installed, trouble-free piping steps-up production schedules!

TUBE-TURN fittings speed up piping installation four ways: (1) Need only butt-welds, easy for veteran or novice welders. (2) Less lining-up, for ings have *uniform* walls and true circularity.) Sections pre-assembled on the ground save ne. (4) Torch cutting and fabricating are minated. Tube-Turn fittings are ready to weld ypes, sizes and weights for all needs.

You can depend on piping welded with Tube-Turn fittings to be practically maintenance-free, as Tube-Turn welding fittings give the *greatest possible strength* and *long life*. They're *permanently leakproof*. There are no bolts to loosen, no gaskets to replace, no threads to corrode and weaken.

No plant *ever* can afford a break-down or production slow-up, but in war-time it's a disaster! The best insurance in the world against trouble in piping systems is *welding* with *Tube-Turn fittings!*

TUBE TURNS, (INC.) LOUISVILLE, KY. ● *Branch Offices*: New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Tulsa, Houston, Los Angeles. ● *Distributors in principal cities.*

TUBE-TURN *Welding Fittings*

TRADE MARK

★

OTHER WAR-TIME ADVANTAGES:

SAVES CRITICAL MATERIAL: Absence of many flanges, bolts, nuts and heavy cast steel construction saves many tons of metal in a single piping system.

FASTER AND EASIER TO INSULATE: Tube-Turn fittings are insulated as easily as the pipe itself, for the welds form one continuous tube.

SAVE SPACE: Pipe systems welded with Tube-Turn fittings permit streamlined, compact layouts and sharp angles.

LAST LONGER: Smooth inner walls—with no ridges, waves or scale—means less corrosion and longer life.

LESS PRESSURE LOSS: Because of full effective radius and exact O.D. and I.D. alignment with the pipe, the flow is more efficient and pressure loss is less.

FEWER SUPPORTS NEEDED: Since welded piping weighs less and stands vibration better than flanged systems, few hangers or supports are required.

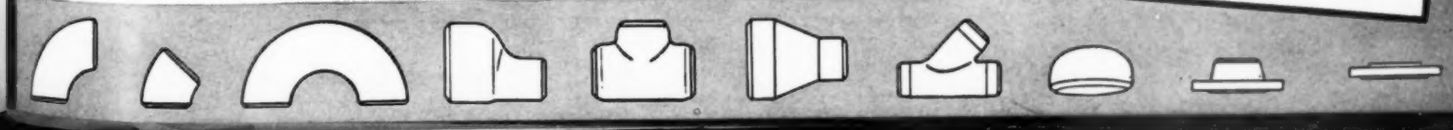


TABLE 6

Single batch extraction with chlorex,* nitrobenzene,† and acetone‡
(200 volumes solvent used to 100 volumes oil in all cases)

	Original oil	Chlorex raffinate	Chlorex extract	Nitrobenzene raffinate	Nitrobenzene extract	Acetone raffinate	Acetone extract
Viscosity at:							
210 °F.	49.0	49.0	55.0	48.0	53.0	48.0	52.0
100 °F.	272.0	233.0	582.0	216.0	406.0	236.0	390.0
Viscosity index	77.5	104.0	5.4	104.5	54.1	89.4	49.8
V. G. C.	0.845	0.828	0.898	0.819	0.817	0.833	0.891
Gravity, A.P.I.	25.8	28.5	18.0	29.8	21.8	27.7	19.8
A.S.T.M. pour point, °F.	0	5	—10	5	—10	0	—15
Yield, volume percent	100.0	74.8	25.2	51.1	48.9	79.2	20.8

*Miscible at 120 °F.; extraction at 77 °F.
†Miscible at 93 °F.; extraction at 50 °F.
‡Miscible at 120 °F.; extraction at 80 °F.
This table appears as Table 27, page 118 of the text.

we study pour-point depressants and will arrive at our own conclusions.

They are intermediate between the lower pour-point western naphthenic oils and the higher pour-point Pennsylvania oils. In dewaxing we removed waxes; in deasphalting we rid the oil of some tars and resins, as well as asphalts, and in refining we remove the low viscosity index oils to a considerable extent.

There are three types of solvent refining methods: (1) Single batch, (2) multiple batch, and (3) counter-current extraction. On single batch extraction we have the formula shown below. We will substitute in the formula at the right, below, figures used for comparison:

$$\frac{\frac{y_1}{P}}{\frac{y_0 - y_1}{W}} = K, \text{ or } \frac{\frac{0.05}{95}}{\frac{0.20 - 0.05}{500}}$$

$$= \frac{0.00053\ (C_1)}{0.00030\ (C_2)}$$

Where:

K = distribution coefficient $\frac{C_1}{C_2}$

where C_1 and C_2 are concentrations of impurities in the oil and solvent phase, respectively,

y_o = concentration of impurities in oil before extraction,

y_1 = concentration of impurities in oil after extraction,

P = volume of oil free of impurities,

W = volume of solvent free of impurities, and

$$C = \frac{KP}{W}.$$

These data give the theoretical aspects of single batch extraction. On page 108 of the text, comparison of the three methods is indicated and it is obvious the counter-current method is more efficient.

The principle is correct, although in actual practice the amounts may fluctate.

Pupil: When a separation is made to reclaim ketone, is that a boiling mixture? Does one have to separate the ketone and benzol or do they come over at the same time?

Pupil: The boiling points are: Methylethyl ketone, and benzol, 175° F., so it would appear they distill off together.

Leader: At the next meeting we shall be back to processing. At present we shall think about what happens and why. The text shows 7 variables encountered in practical application of the different processes:

(1) Nature of solvent (selective and low solvent power for good oil),

(2) Quantity of solvent,

(3) Temperature of extraction (control to optimum point),

(4) Contacting time (requires careful adjustment),

(5) Settling time (drums of proper size),

(6) Method of contact (counter-contact favored),

(7) Nature of extracted oil.

What does "selectivity" mean to you?

Pupil: The solvent will act on one and maybe not on the other; or more on one than on the other.

Leader: We are going to improve the viscosity index number and in doing so we are to select the one that gives the most selectivity.

Pupil: The one that gets rid of unwanted material and retains more of the wanted material.

Leader: Apply this definition to Table 26, page 117 of the text. (Table 5 of this article.) Of the first two shown (100 percent aniline and 50 percent nitrobenzene), which shows greater selectivity?

Pupil: Aniline.

Leader: Which has the higher solvent power?

Pupil: Nitrobenzene.

Leader: We want the one of greater selectivity and lower solvent power. In the next two (200 percent aniline and 45 percent nitrobenzene)?

Pupil: Aniline is a better solvent for Coastal distillate of 65 Saybolt. It seems to me the latter solvent would be more expensive.

Leader: Under the conditions described, it would appear the advantage is in aniline.

Leader: Of the last (100 percent aniline and 100 percent nitrobenzene) what is your opinion?

Pupil: You will obtain a lower yield on nitrobenzene but higher viscosity index.

Pupil: You must choose between yield and viscosity index.

Leader: Again we are faced with a question of economics. Reading from the text: "Under the above conditions of extraction, however, the quantity of aniline required to raise the viscosity index of the oil to that obtained with 100 percent nitrobenzene is prohibitive. . ." If you selected the aniline to get given results, then you might make a mistake. Also in the text: ". . . in preparing an oil of a relatively low viscosity index, aniline at 75°F. would be preferred, while for a relatively high viscosity index oil nitrobenzene at 35°F. is more practical."

Pupil: Which is more selective?

Pupil: Aniline is more selective but nitrobenzene is a better solvent.

Leader: In projecting the curves to the ultimate, the aniline curve is steeper and therefore more selective. To reach

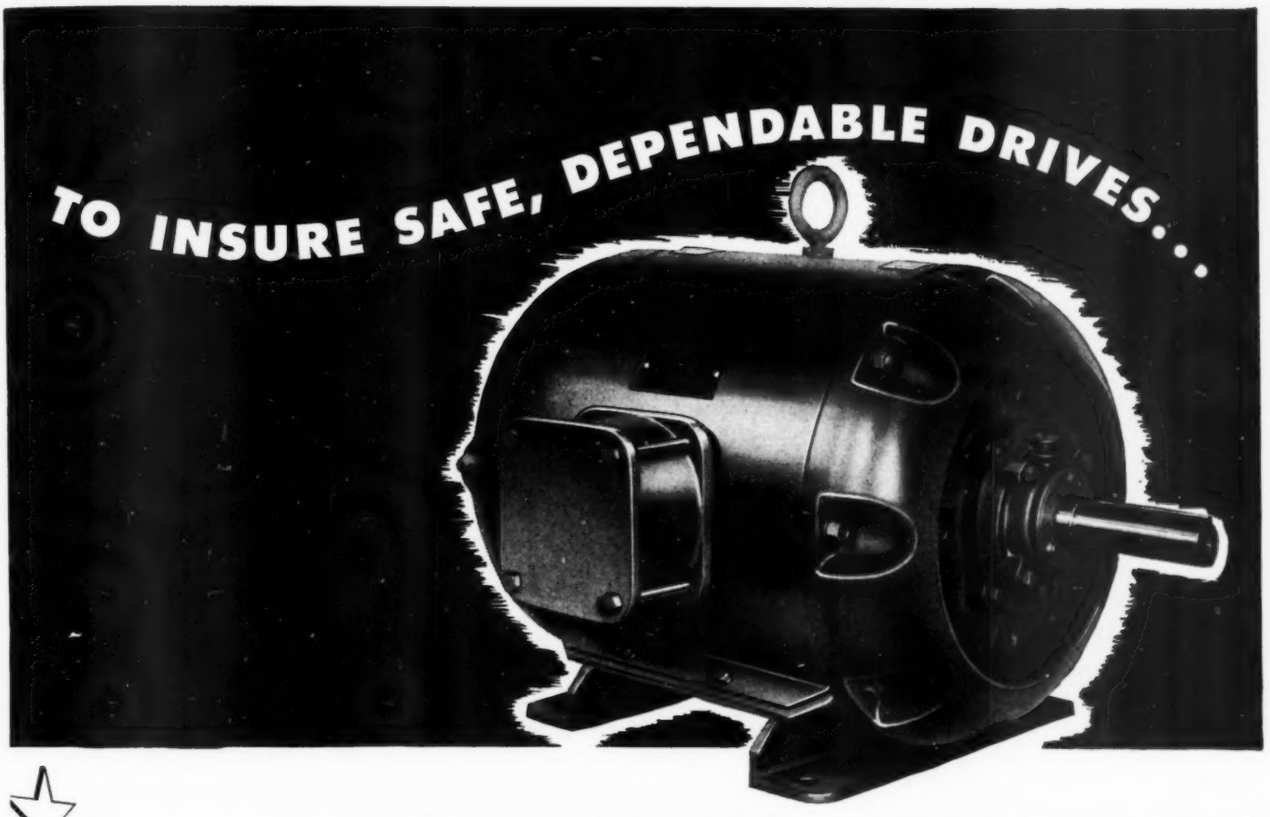
TABLE 7

Effect of quantity of solvent used in refining

Solvent, percent by volume	Raffinate				
	Yield, percent	Gravity, °A.P.I.	S.U.V. at 210°F.	Viscosity index	Carbon residue
Original stock	100.0	21.4	130.0	65.0	2.9
Furfural at 200 °F.:					
300	75.2	25.7	108.6	84.7	1.1
600	62.6	26.6	107.8	88.6	0.9
900	53.3	27.1	107.0	91.0	0.8
1200	47.1	27.3	106.4	93.2	0.7
Chlorex at 80 °F.:					
300	70.0	26.0	108.8	85.4	1.0
600	59.1	26.9	106.2	89.5	0.8
900	50.4	27.5	104.6	93.6	0.7
1200	44.8	27.6	104.2	95.7	0.6
Phenol at 150 °F.:					
300	66.3	25.9	108.2	87.5	1.0
600	50.0	27.8	107.0	92.8	0.8
900	40.8	28.0	104.2	95.4	0.7
1200	34.0	28.2	104.0	97.5	0.6

This table appears as Table 28, page 119 of the text.

TO INSURE SAFE, DEPENDABLE DRIVES...



☆ *Specify* WAGNER MOTORS

Your best protection against production delays and unnecessary expense is to specify Wagner Type HP motors on all motor-driven equipment. They have been tested and approved by the Underwriters' Laboratories for Class 1 Group D hazardous locations.

The type HP motor illustrated is only one of the many Wagner motors built to meet the tough operating conditions in the oil fields, refineries, and chemical plants.

WAGNER TRANSFORMERS

Fire is one of the outstanding menaces in the oil and chemical industries. Every precaution should be taken to prevent this hazard. Wagner Noflamol transformers can help because they are filled with a non-inflammable, synthetic liquid. In addition to the Noflamol transformers, Wagner builds all types and sizes of distribution and power transformers.

● *Write for Complete Literature!*

E 3-2

FIELD ENGINEERING SERVICE!

HOUSTON, TULSA, LOS ANGELES, CLEVELAND, NEW YORK . . . and all of the rest of Wagner's 25 Branches are manned by trained field engineers competent to solve your motor and transformer application problems. For information on Wagner Motors for the oil and chemical industries, write for Bulletin MU-182.

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

Wagner Electric Corporation

6400 Plymouth Avenue, Saint Louis, Mo., U.S.A.

100 viscosity index number with the aniline, we would have a yield of around 50 percent; however, economics might be undesirable. The nitrobenzene curve would give a yield of around 30 percent.

In Table 27 on page 118 of the text (Table 6 of this article) the original oil is Mid-Continent oil and you extract with chlorex first. You will have viscosity index on the raffinate of 104.0; 5.4 on the chlorex extract, and 104.5 on the nitrobenzene raffinate. Which of these three has greatest selectivity?

Pupil: Chlorex.

Leader: What would you expect on the yield if you had the job of making 100 viscosity index? Which would you use?

Pupil: Chlorex.

Leader: You could expect a 75 percent yield on chlorex.

By varying quantities of solvents you can get about the same general yield but the economics would be very different and each division would require its own analysis.

The distribution qualification enters into the nature of the solvent in deciding which is to be used.

In Table 28, on page 119 of the text (Table 7 of this article), we have the following: Furfural at 200°F.; Chlorex at 80°F., and phenol at 150°F.

What oil is used in this table, 21.4 A.P.I. gravity?

Pupil: Mid-Continent cylinder stock.

Leader: Of those shown in Table No. 28, which is most selective?

Pupil: Chlorex and furfural.

Leader: Furfural is probably best.

Pupil: Phenol will give you a better viscosity index.

Leader: Suppose you want to make 95 or above, what about your yield?

Pupil: Chlorex appears to have some advantage.

Leader: What about Duo-sol?

In Table 29, page 120, of the text (Table 8 of this article) we have the same solvent used in all cases.

What is shown by this comparison?

Pupil: If you increase the solvent power, you decrease the selectivity.

Leader: It is necessary to control to the optimum point.

Leader: What do you think all this leads to?

Pupil: An experimental plant.

Leader: The first thing to do is to experimentally determine the final outcome. If we have a mixture of solvent and oil through a mixer into a settler, it would be a single contact unit. If we just repeat this and put in fresh solvent all the way through would that be a multiple batch process?

TABLE 8
Effect of temperature on selectivity and solvent power

Temperature of extraction	*Yield percent*	*Viscosity index*
32°F.	90	33
75°F.	85	40
100°F.	80	36

This table appears as Table 29 on page 120 of the text.

Pupil: I think so.

Leader: The first time you contact you have a given extract heavy in gravity. Suppose you achieve the separation and go on and on; what would happen to the gravity?

Pupil: The gravity is higher on the extract and on the oil.

Leader: There is probably no limit to the high gravity. We should limit the time through the batches. Fig. 12 on page 122 of the text (Fig. 13 in this article) shows the effect of extraction methods on the amount of chlorex to make an oil of known viscosity index.

The last phase is counter-current contact. There are several ways this can be done. Probably one of the best ways is through a tower. The solvents are heavier than the oil and settle down through the oil in the tower. What about the time of settling?

Pupil: Time of contact and time of settling have to be worked out in counter-current process.

Pupil: In some processes the solvent used harms the time and the settling rate.

Leader: In general, the time of settling is longer for oils containing wax and asphalts in suspension. They act as emulsifying agents. Increased temperatures increase the settling rates. You would have to be certain you did not plug-up the equipment; if you did, a different distillate would have to be used. What other ways are suitable?

Pupil: Agitation by motor-driven equipment.

Pupil: Inert gas.

Leader: How about mixers?

Pupil: A cyclone type mixing device might be all right.

Pupil: What would be the disadvantage in having oil and solvent in contact and mix it as it comes through a pump?

Leader: That would depend upon your control of the proportion of solvent to the oil. The counter-current method is favored.

If you don't get good contact, what will happen in the quantity of solvents used?

Pupil: They will increase.

Leader: Yes, this is a very vital factor.

Pupil: In connection with speeding-up settling time by heating oil, would that affect the solvent action?

Leader: The temperatures used are limited according to the nature of the solvent used.

Pupil: You can't take any one of the seven variables and consider it alone. I believe that each ties in with the other. One might have better properties and still not be the one to use.

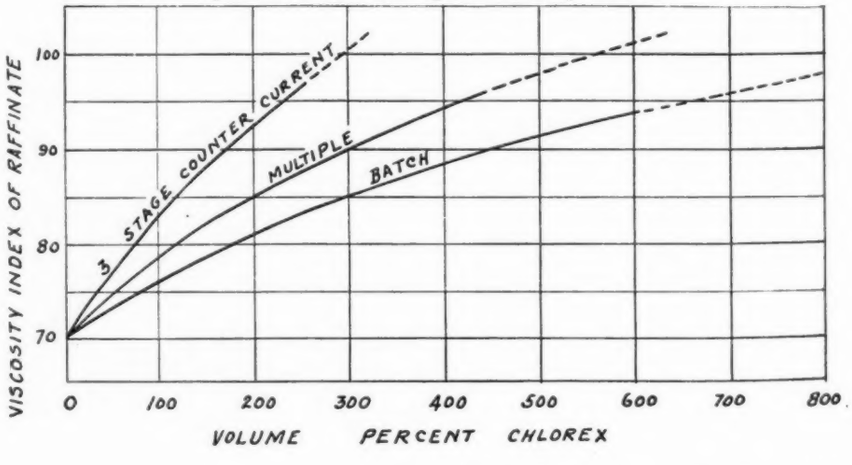
Leader: If you are seeking a very high viscosity index number oil you may have an intermediate product. You may want to recycle that intermediate material. The seven variables are the factors to use in determining which solvent to use.

The nature of the extract should be studied in advance to determine what is to be done in the future. You might use a solvent that gives very poor separation but you might be able to work on that extract and produce high viscosity index oil. Without experimental facilities it is impossible to determine the nature of the extract in advance.

(To be Continued)

☆ ☆ ☆

Fig. 13. Effect of extraction methods on the amount of chlorex required to produce an oil of a given viscosity index



The compressor units have a combined horsepower of 1530

Features of New Lone Star Compressor Station

PETROLEUM ENGINEER Exclusive Feature

☆ **Designed to deliver gas at rate of 48,000,000 cu. ft. per day with suction pressure of 130 lb. and discharge pressure of 230 lb.**

by Frank H. Love
Managing Editor

AN INCREASED gas load, necessitated by fuel requirements for war industries, army camps, and air fields, has required the construction of a 1530-hp. compressor station near Waco, Texas, by the Lone Star Gas Company. Recently Lone Star laid a number of loops to fields in Anderson and Leon counties to obtain a greater gas supply for the several consumption points in the area. In case of necessity the East Texas gas also can be sent north to serve the Dallas-Fort Worth area, normally supplied by West Texas fields.

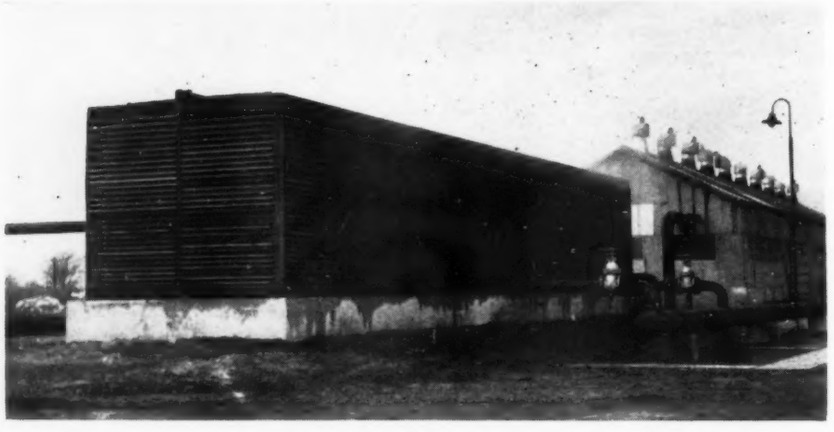
The compressor plant is designed to deliver gas at the rate of 48,000,000 cu. ft. a day with a 130-lb. suction and 230-lb. discharge pressure. Immediately upon arriving at the station the gas passes through two cleaners before entering the suction of the compressor units. The latter consist of nine twin engines each having a rated horsepower of 170 with a 12-in. bore and 20-in. stroke. There are two 8-in. by 20-in. compressors direct-connected to each engine. All engines are secondhand equipment, rebuilt before being placed in service. A feature of the station is the fact that it was constructed largely of salvaged equipment and materials. In addition to new parts used in rebuilding the compressors and engines, the cooling tower, cleaners, and the pumps are new; otherwise the equipment is secondhand.

When the gas is discharged from the compressors at a pressure of 230 lb. it passes through a bank of cooling coils in a cooling tower 12 ft. by 66 ft. by 12 ft. high before entering the main transmission line.

Water Supply

Water is supplied from a 17-ft. well, and is treated for hardness before entering the system. The water is lifted by a shallow-well centrifugal pump, rated capacity of 1980 gal. per hr., driven by a ½-hp. motor. The water flows to the pit of the cooling tower through a ¾-in. line. An 80-hp., 2-cycle gas engine, situated in the auxiliary building, drives two 1750-r.p.m. centrifugal pumps. One of these pumps picks up water from the pit and discharges it over the top of the cooling tower at the rate of 1300 gal. per min. against a 60-ft. head. The other pump

An 80-hp., 2-cycle gas engine driving two centrifugal water-circulating pumps



This tower serves to cool the gas before it enters the transmission line as well as the engine jacket water

circulates water through the enclosed jacket water system at the rate of 750 gal. per min. Water for jacket cooling is pumped first to a 4245-gal. overhead tower, then to the water treater, and into a surge tank that maintains the water level on the system. The water is circulated in a continuous cycle from the engine jackets through a bank of coils in the cooling tower. This system serves the auxiliary engines as well as the compressor engines.

Another 80-hp., 2-cycle gas engine driving centrifugal pumps is situated in the auxiliary building to serve as standby water-circulating equipment.

Lubricating System

To lubricate the compressor engines oil is pumped over the engine bearings by a 3 by 2 by 3 reciprocating pump from where it gravitates to the crankcase, thence to a sump from which it is picked up by the pump and discharged through a filter back to the engine bearings. As the oil level in the sump drops new oil is added. The pump is operated by about 40-lb. gas pressure. This gas is not wasted, as the exhaust gas enters the fuel header to the compressor units. A pump of the same size serves as a standby. On the cylinder end separate force-feed lubricators are provided for each unit.

The 8-in. exhaust lines from the engines pass through an 18-in. casing. Built into the exhaust line, and also within the casing, is a 14-in. O.D., 10 ft. long mineral wool silencer.

All fuel, starting air, exhaust, and lubricating oil lines are beneath the floor but above ground level. The floor level is 4 ft. above the ground line to protect against possible overflow from the nearby Brazos River, making it possible for the lines mentioned to be under the floor out of the way, yet not buried. They are thus accessible for inspection or repair and soil corrosion is reduced.

Electric power is generated by a 15-kw. a-c. generator driven by a 6-cylinder gas engine. The power thus provided serves the station, yard, and cottages.

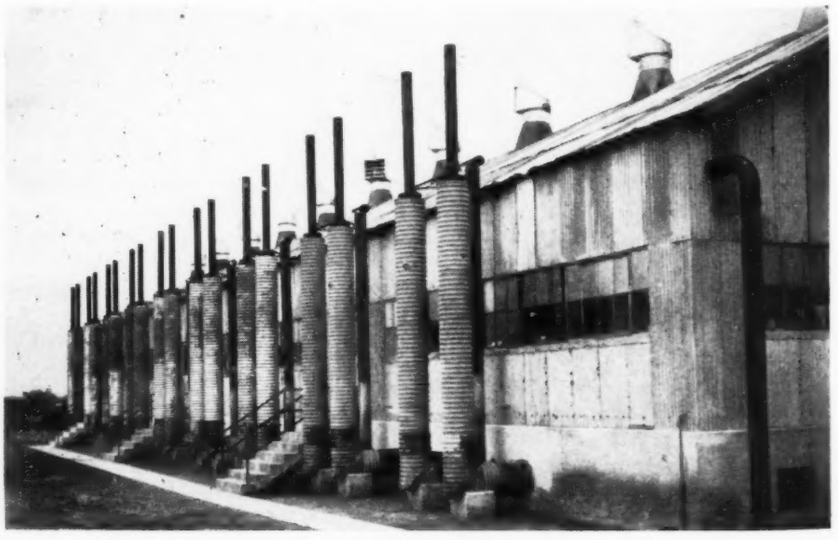
Starting air is provided by a 6½ by 3½ by 4 angle 2-stage air compressor.

Buildings

The buildings are built on foundations 4 ft. above ground level and all floors are of concrete. The main compressor building and the auxiliary building are constructed of a steel framework covered with corrugated iron. The compressor building is 141 ft. 3½ in. long by 31 ft. 7 in. wide by 12 ft. high. The auxiliary building is 57 ft. 3½ in. long by 31 ft. 7 in. wide by 12 ft. high. The office building is of frame construction, and to house the operating personnel there are three standard 5-room cottages.

The Lone Star engineering department designed and supervised construction of the station.

☆ ☆ ☆



The 8-in. exhaust lines are inside 18-in. casings, as shown. A silencer built into each exhaust line is also within the casing

Calculation of Orifice Meter Coefficients

☆ Growing shortage of trained personnel makes pertinent a discussion of basic values in gas measurement

PETROLEUM ENGINEER Exclusive Feature

by J. W. J. Bercher

Tide Water Associated-Seaboard Oil Company

THE increased importance of gas measurement in the petroleum industry, together with a growing shortage of adequately trained personnel, indicate the importance of a discussion of basic values.

The formulas developed by Buckingham and Bean and published in the Appendix to A.G.A. Gas Measurement Committee Report No. 2 May 6, 1935, should be familiar to everyone engaged in gas measurement work.

The first step, and perhaps the most important, in computing an orifice meter coefficient is the determination of the basic orifice flow factor, F_b, which is constant for a given installation and is entirely dependent upon plate and line sizes. Unless the meterman is capable of computing values of F_b, the original value is likely to be retained upon the records after the plate has been cut to such an extent that appreciable errors in measurement are introduced.

The formulas used, in the order of their application, are as follows:

1. $\beta = \dfrac{D_2}{D_1}$

Where:

β = ratio of orifice diameter to upstream pipe diameter,

D_2 = diameter of the orifice (± 0.001), and

D_1 = diameter pipe at upstream pressure connection (actual I.D. ± 0.001).

2. For flange taps:

$$K_e = 0.5993 + \frac{0.007}{D_1} + \left(0.364 + \frac{0.076}{\sqrt{D_1}}\right)\beta^4 + 0.4\left(1.6 - \frac{1}{D_1}\right)^5 \left[\left(0.07 + \frac{0.5}{D_1}\right) - \beta\right]^{5/2} - \left(0.009 + \frac{0.034}{D_1}\right)(0.5 - \beta)\Big)^{3/2} + \left(\frac{65}{D^2_1} + 3\right)(\beta - 0.7)^{5/2}$$

For pipe taps:

$$K_e = 0.5925 + \frac{0.0182}{D_1} + \left(0.440 - \frac{0.06}{D_1}\right)\beta^2 + \left(0.935 + \frac{0.225}{D_1}\right)\beta^5 + 1.35\beta^{14} + \frac{1.43}{\sqrt{D_1}}(0.25 - \beta)^{5/2}$$

Where:

K_e = coefficient of discharge when the Reynold's number is equal to $(10^6 \times D_2)/15$

For either pair of taps:

3. $$K_o = \frac{K_e}{1 + \dfrac{15E}{10^6 \times D_2}}$$

Where:

K_o = The coefficient of discharge for infinite Reynold's number.

The value of E is given by the following equation:

4. $E = D_2(830 - 5000\beta + 9000\beta^2 - 4200\beta^3 + \beta)$

Where:

5. $B = \dfrac{530}{\sqrt{D_1}}$, flange taps.

$B = \dfrac{875}{D_1} + 75$, pipe taps.

6. $F_b = 345.92\ D^2_2 \times K_o$

Normally, no trouble will be had with any of the above except the formula for the value of K_e. The fractional exponents cause many to give up before an effort is made, but as Sylvanus Thompson once said in the preface to a calculus text, "What one fool can do another can do." There is no reason why anyone who can learn to service an orifice meter cannot learn to calculate the necessary coefficients. The fractional exponent means only that two operations are to be performed, a root must be found and a power of the root determined. For example, $(0.5 - \beta)^{3/2}$ means only that when a value is found for β and substituted that the square root of the resulting value is to be raised to the 3rd power. If $\beta = 0.25$, then $(0.5 - 0.25)^{3/2}$ will reduce to $(\sqrt{0.25})^3$, or $(0.5)^3$, or 0.125. If many calculations of this nature are to be made, a set of logarithms such as "Vega's Logarithmic Tables" published by Van Nostrand is of real value. The advantage in using these, or similar 7 place tables, is principally in the fact that results to 5 significant figures may be read directly without interpolation.

In solving for K_e certain terms will be found to contain $\sqrt{-1}$ as a coefficient. Such terms are to be dropped, as no real value for them can be found. With practice the computer will be able to determine which terms will give $\sqrt{-1}$ as a coefficient by inspection and will not find it necessary to set up such terms in his calculations. For the benefit of those who are not yet fully familiar with the use of the formula the following may prove useful. In computing the value of K_e for flange taps the first

J. W. J. BERCHER

attended Missouri School of Mines, Rolla, Missouri, 1926-27; Cameron State Junior College, Lawton, Oklahoma, 1931; Air Corps Technical School, Chanute Field, Illinois, 1932—Employed by various pipe-line contractors, 1925-29—With Sure Shot Torpedo Company, Huntington, West Virginia, 1930—Entered U. S. Army Air Corps, 1931—Employed by Tidal Pipe Line Company, 1935; worked as line walker, clerk, and pumper—Transferred to Tide Water Associated-Seaboard Oil Company's Cayuga Recycling Plant No. 1 as laboratory-meter man in 1938—In 1940 was promoted to assistant plant foreman in charge of Cayuga Recycling Plant No. 2.

three terms, that is $0.5993 + \frac{0.007}{D_1} + \left(0.364 + \frac{0.076}{\sqrt{D_1}}\right)\beta^4$, will appear for any value of β. If β is greater in value than, or equal to, $\left(0.07 + \frac{0.5}{D_1}\right)$ then the fourth term $\left\{0.4\left(1.6 - \frac{1}{D_1}\right)^5 \left[\left(0.07 + \frac{0.5}{D_1}\right) - \beta\right]^{5/2}\right\}$ will disappear. If β is greater than or equal to 0.5 the fifth term $\left[\left(0.009 + \frac{0.034}{D_1}\right)(0.5 - \beta)^{3/2}\right]$ will disappear. If β is less than or equal to 0.7 the sixth term $\left(\left(\frac{65}{D_2} + 3\right)(\beta - 0.7)^{5/2}\right)$ will drop out. Or it may be desirable to write the formulas applicable to various values of β for direct reference, as by specification the extreme values of β will range from 0.10 to 0.75 for flange taps and from 0.10 to 0.70 for pipe taps with a recommended range of 0.15 to 0.70 for flange taps and 0.20 to 0.67 for pipe taps. Use of these values makes it possible to set up the following equations, which may be used directly for the various values of β noted:

When β is less than 0.5:

$$K_e = 0.5993 + \frac{0.007}{D_1} + \left(0.364 + \frac{0.076}{\sqrt{D_1}}\right)\beta^4 + 0.4\left(1.6 - \frac{1}{D}\right)^5 \left[0.07 + \frac{0.5}{D_1}\right) - \beta\Big]^{5/2} - \left(0.009 + \frac{0.034}{D_1}\right)(0.5 - \beta)^{3/2}$$

$0.7 > \beta < 0.5$

When β is less than 0.7 but greater than 0.5:

$$K_e = 0.5993 + \frac{0.007}{D_1} +)0.364 + \frac{0.076}{\sqrt{D_1}}\beta^4 + 0.4\left(1.6 - \frac{1}{D}\right)^5 \left[0.07 + \frac{0.5}{D_1}\right) - \beta\Big]^{5/2}$$

When β is greater than 0.7:

$$K_e = 0.5993 + \frac{0.007}{D_1} + \left(0.364 + \frac{0.076}{\sqrt{D_1}}\right)\beta^4 + 0.4\left(1.6 - \frac{1}{D}\right)^5 \left[0.07 + \frac{0.5}{D_1}\right) - \beta\Big]^{5/2}$$

TABLE 1
Values of terms used in A.G.A. formula for finding K_e for flange taps for various values of D_1

Nominal pipe size, in.	Schedule number	t	D_1	$\frac{0.007}{D_1}$	$0.364 + \frac{0.076}{\sqrt{D_1}}$	$\left(1.6 - \frac{1}{D_1}\right)^5$	$0.07 + \frac{0.5}{D_1}$	$0.009 + \frac{0.034}{D_1}$	$\frac{65}{D_1} + 3$
	40	0.216	3.068	0.002282	0.407390	3.35691	0.232972	0.020082	9.90562
	..	0.241	3.018	0.002319	0.407748	3.28644	0.235672	0.020266	10.13633
	..	0.254	2.992	0.002340	0.407937	3.24931	0.237112	0.020364	10.26090
3	..	0.289	2.922	0.002396	0.408460	3.14779	0.241116	0.020636	10.61295
	80	0.300	2.900	0.002414	0.408629	3.11539	0.242414	0.020724	10.72889
	..	0.312	2.875	0.002438	0.408822	3.07833	0.243913	0.020826	10.86390
	..	0.406	2.687	0.002605	0.410364	2.85468	0.256031	0.021654	12.00281
	160	0.437	2.626	0.002666	0.410899	2.69375	0.260404	0.021947	12.42592
	..	0.600	2.300	0.003043	0.414113	2.14803	0.287392	0.023783	15.28730
	40	0.266	3.548	0.001973	0.404348	3.97946	0.210924	0.018583	8.47198
	..	0.281	3.438	0.002036	0.404988	3.84516	0.215434	0.018889	8.49923
3½	80	0.318	3.364	0.002081	0.405437	3.75222	0.218632	0.019107	8.74382
	..	0.344	3.312	0.002114	0.405761	3.68545	0.220966	0.019266	8.92561
	..	0.469	3.062	0.002286	0.407432	3.34856	0.233292	0.020104	9.93271
	..	0.636	2.728	0.002566	0.410014	2.85478	0.253284	0.021463	11.73423
	40	0.237	4.026	0.001739	0.401877	4.52786	0.194192	0.017445	7.01022
	..	0.250	4.000	0.001750	0.402000	4.48404	0.195000	0.017500	7.06250
	..	0.271	3.958	0.001768	0.402201	4.44020	0.196326	0.017590	7.14916
	..	0.281	3.938	0.001778	0.402298	4.41914	0.196968	0.017634	7.19144
	..	0.300	3.900	0.001795	0.402484	4.37858	0.198205	0.017718	7.27350
4	..	0.312	3.876	0.001806	0.402603	4.35274	0.198999	0.017772	7.32658
	80	0.337	3.826	0.001830	0.402854	4.29836	0.200685	0.017887	7.44041
	..	0.375	3.750	0.001867	0.403246	4.21552	0.203334	0.018067	7.62222
	120	0.437	3.626	0.001931	0.403912	4.07173	0.207893	0.018377	7.94376
	..	0.500	3.500	0.002000	0.404624	3.92153	0.212857	0.018714	8.30612
	160	0.531	3.438	0.002036	0.404988	3.84516	0.215434	0.018889	8.49925
	..	0.674	3.152	0.002221	0.406807	3.47291	0.228630	0.019787	9.54246
	40	0.258	5.047	0.001387	0.397830	5.41407	0.169069	0.015737	5.55180
	..	0.352	4.859	0.001441	0.398478	5.26775	0.172902	0.015997	5.75308
	80	0.375	4.813	0.001454	0.398642	5.23064	0.173886	0.016064	5.80596
5	..	0.437	4.688	0.001493	0.399101	5.12740	0.176655	0.016252	5.95760
	120	0.500	4.563	0.001534	0.399578	5.02033	0.179577	0.016451	5.12185
	160	0.625	4.313	0.001623	0.400595	4.79350	0.185928	0.016883	5.49425
	..	0.750	4.063	0.001723	0.401704	4.54884	0.193062	0.017368	5.93748
	40	0.280	6.065	0.001154	0.394860	6.08753	0.152440	0.014606	4.76706
	..	0.375	5.875	0.001191	0.395355	5.97533	0.155106	0.014787	4.88321
	80	0.432	5.761	0.001215	0.395664	5.90523	0.156790	0.014902	4.95847
6	..	0.500	5.625	0.001244	0.396044	5.81881	0.158889	0.015044	5.05432
	120	0.562	5.501	0.001272	0.396404	5.69996	0.160892	0.015181	5.14798
	160	0.718	5.189	0.001349	0.397363	5.53226	0.166358	0.015552	5.41405
	..	0.864	4.897	0.001429	0.401217	5.29786	0.172102	0.015943	5.71052

TABLE 2
Values of terms used in A.G.A. formula for finding K_e for pipe taps for various values of D_1

Nominal pipe size, in.	Schedule number	t	D_1	$\frac{0.0182}{D_1}$	$\frac{0.06}{D_1}$	$\frac{0.225}{D_1}$	$\frac{1.43}{\sqrt{D_1}}$
	40	0.216	3.068	0.005932	0.019557	0.073338	0.816410
	..	0.241	3.018	0.006030	0.019881	0.074553	0.823145
	..	0.254	2.992	0.006083	0.020053	0.075200	0.826714
3	..	0.289	2.922	0.006229	0.020554	0.077002	0.836556
	80	0.300	2.900	0.006276	0.020690	0.077586	0.839734
	..	0.312	2.875	0.006030	0.020870	0.078261	0.843369
	..	0.406	2.687	0.006773	0.022330	0.083736	0.872371
	160	0.437	2.626	0.006931	0.022848	0.085682	0.882449
	..	0.600	2.300	0.007913	0.026087	0.097826	0.942911
	40	0.266	3.548	0.005130	0.016911	0.063416	0.759180
	..	0.281	3.438	0.005294	0.017452	0.065445	0.771230
3½	80	0.318	3.364	0.005410	0.017836	0.066885	0.779665
	..	0.344	3.312	0.005495	0.018116	0.067935	0.785762
	..	0.469	3.062	0.005944	0.019595	0.073481	0.817208
	..	0.636	2.728	0.006672	0.021994	0.082478	0.865790
	40	0.237	4.026	0.004521	0.014903	0.055887	0.712687
	..	0.250	4.000	0.004550	0.015000	0.056250	0.715000
	..	0.271	3.958	0.004598	0.015159	0.056847	0.718784
	..	0.281	3.938	0.004622	0.015236	0.057136	0.720606
	..	0.300	3.900	0.004667	0.015385	0.057692	0.724100
	..	0.312	3.876	0.004696	0.015480	0.058050	0.726346
4	80	0.337	3.826	0.004757	0.015682	0.058808	0.731106
	..	0.375	3.750	0.004853	0.016000	0.060000	0.738449
	120	0.437	3.626	0.005019	0.016547	0.062052	0.750968
	..	0.500	3.500	0.005200	0.017143	0.064286	0.764367
	160	0.531	3.438	0.005294	0.017452	0.065445	0.771264
	..	0.674	3.152	0.005774	0.019036	0.071383	0.805616
	40	0.258	5.047	0.003606	0.011888	0.044581	0.636532
	..	0.352	4.859	0.003746	0.012348	0.046306	0.648732
	80	0.375	4.813	0.003781	0.012466	0.046748	0.651819
5	..	0.437	4.688	0.003882	0.012799	0.047995	0.660453
	120	0.500	4.563	0.003989	0.013149	0.049310	0.669438
	160	0.625	4.313	0.004220	0.013911	0.052168	0.688566
	..	0.750	4.063	0.004480	0.014767	0.055378	0.709568
	40	0.280	6.065	0.003166	0.009893	0.037098	0.580659
	..	0.375	5.875	0.003098	0.010213	0.038298	0.589973
	80	0.432	5.761	0.003159	0.010415	0.039056	0.595781
6	..	0.500	5.625	0.003236	0.010667	0.040000	0.602940
	120	0.562	5.501	0.003308	0.010907	0.040902	0.609699
	160	0.718	5.189	0.003507	0.011563	0.043361	0.627760
	..	0.864	4.897	0.003716	0.012252	0.045946	0.646205

TABLE 3
Value of B for various values of D_1

B_1 flange taps $\frac{530}{\sqrt{D_1}}$	B_1 pipe taps $\frac{875}{D_1} + 75$
302.586	360.202
305.082	364.927
306.404	367.446
310.052	374.452
311.230	376.724
312.577	379.348
323.326	400.642
327.062	408.206
349.470	455.435
281.374	321.618
285.841	329.509
288.967	335.107
291.226	339.190
302.881	360.761
320.887	395.748
264.143	292.337
265.000	293.750
266.403	296.071
267.078	297.194
268.376	299.359
269.305	300.748
270.958	303.699
273.691	308.334
278.331	316.313
283.297	325.000
285.841	329.509
298.526	352.602
235.917	248.371
240.439	255.078
241.583	256.800
244.783	261.646
248.113	266.760
255.203	277.875
262.937	290.358
215.209	219.270
218.661	223.936
220.814	226.883
223.467	230.556
225.972	234.062
232.666	243.626
239.502	253.681

It will be noted that the fourth term was retained in each of the above. This is due to the value of this term being dependent upon both β and D_1, making a rule based upon β alone impossible. Inspection of the value $\left(0.07 + \frac{0.5}{D_1}\right) - \beta$ for various pipe sizes will make this clear. The term $\left(0.07 + \frac{0.5}{D_1}\right)$ will have values for various pipe sizes as follows:

1 in. = 0.57	4 in. = 0.20
2 in. = 0.32	5 in. = 0.17, etc.
3 in. = 0.24	

As β must be less than the value of $\left(0.07 + \frac{0.5}{D_1}\right)$ if the fourth term is to be retained, it is easily seen that one may very quickly decide whether to use this term from a comparison of the pipe size and the value of β.

Similarly, it is readily seen that in the equation for the determination of K_e for pipe taps, the last term drops out if β is less than 0.25.

At this point it may be well to determine the value of F_b for a specific installation. In cases where values are calculated it is usually desirable, in accordance with methods used in preparing the tables contained in the A.G.A. Gas Measurement Report No. 2, to carry out the intermediate steps to six significant figures and to round off the final value to the fifth significant figure. When the sixth figure is five the fifth figure is taken as the nearest even figure. Uniform adherence to this rule will make it possible for different computers to check more closely than would otherwise be possible. For a meter setting using flange taps where $D_1 = 2.900$ in. and $D_2 = 2.000$ in. the calculation of F_b would be (employing logarithms):

$$\beta = \frac{D_2}{D_1} = \frac{2.0}{2.9} = 0.68966$$

Log 2.0 — 0.3010300
Log 2.9 — 0.4623980

Log β — $\bar{1}$.8386320

Note: It is usually most convenient to find values of β^2, β^3, and β^4 at this point by logarithms.

Log $\beta^2 = 2 \times \bar{1}.8386320 = \bar{1}.6772640$
$B^2 = 0.47562$

Log $\beta^3 = 3 \times \bar{1}.8386320 = \bar{1}.5158960$
$B^3 = 0.32802$

Log $\beta^4 = 4 \times \bar{1}.8386320 = \bar{1}.3545128$
$B^4 = 0.22622$

$$K_e = 0.5993 + \frac{0.007}{D_1} + (0.364 + \frac{0.076}{\sqrt{D_1}})\ \beta^4$$

(This value is correct for K_e as β is less than 0.7 and greater than 0.5 and as $(0.07 + \frac{0.5}{D_1}$ is less than $\beta)$.

Log 0.007 = $\bar{3}$.8450980
Log D_1 = Log 2.9 = 0.4623920
Log (0.007 ÷ 2.9) = $\bar{3}$.3827060
$\frac{0.007}{2.9}$ = 0.0024138
Log 0.076 = $\bar{2}$.8808136
Log $\sqrt{D_1}$ = ½ Log D_1 = 0.2311960
Log (0.076 ÷ $\sqrt{D_1}$ = $\bar{2}$.6496176
$\frac{0.076}{\sqrt{2.9}}$ = 0.44629

Then, substituting:

$K_e = 0.5993 + 0.00241 + (0.364 + 0.04463)\ 0.22622$
Log (0.364 + 0.04463)
= Log 0.40863 = $\bar{1}$.6113302
Log β^4 = $\bar{1}$.3545280
$\bar{2}$.9658582
(0.364 + 0.04463) 0.22622 = 0.09244

K_e = 0.5993
0.00241
0.09244
0.69415

$B = \frac{530}{\sqrt{D_1}} = 311.23$

Log 530 = 2.7242759
Log $\sqrt{D_1}$ = 0.2311960
2.4930799
Log B = 311.23

$E = 2\ [830 - (5000 \times 0.68966) + (9000 \times 0.47562) - (4200 \times 0.32802) + 311.23]$
$= 2(830 - 3448.3 + 4280.6 - 1377.7 + 311.23)$

0.68966	0.47562	0.32802	830	3448.3
5000	9000	4200	4280.6	1377.7
3448.30000	4280.58000	6560400	311.23	4826.0
		131208	5421.83	
		1377.68400	4826.00	
			595.83	

$E = 2(595.8) = 1191.6$

$$K_o = \frac{0.69415}{1 + \frac{15 \times 1191.6}{2000000}} = \frac{0.69415}{1 + \frac{17874}{2000000}} = \frac{0.69415}{1.0089}$$

1191.6
15
59580
11916
17874.0

Log 0.69415 = $\bar{1}$.8414533
Log 1.0089 = 0.0038481
Log K_o = $\bar{1}$.8376052
K_o = 0.68803

$K_o = 0.68803$
$F_b = 355.92 \times 2^2 \times 0.68803 = 952.01$

Log 345.92 = 2.5389757
Log 2^2 = 0.6020600
Log 0.68803 = $\bar{1}$.8376052
Log F_b = 2.9786409
F_b = 952.01

It is recommended, that in every case, all work should be shown for convenience in checking.

Tables 1, 2, and 3 will be of value to those who compute coefficients. After receiving several suggestions that a tabulation of orifice coefficients for heavy pipe be prepared, the writer concluded that a tabulation of all values that are dependent upon the inside diameter of the pipe, and which are used in A.G.A. formulas, for each of the nominal sizes 3-in., 3½-in., 4-in., 5-in., and 6-in. (Schedule 40 and heavier), would probably prove of greater value to the industry than would a tabulation of values of F_b arranged as is customary in increments of ⅛ in. for values of D_2.

The tables were prepared from values of D_1 taken from "Table of Properties of Pipe," page 42, Tube-Turn Catalog and Data Book, No. 109, published by Tube Turns, Inc., Louisville, Kentucky.

In preparing the tables values of D^2_1, $\sqrt{D_1}$, and $\frac{1}{D_1}$ were found. In the case of values depending upon $\frac{1}{D_1}$, the values of the terms were taken from multiplication with the value of $\frac{1}{D_1}$ carried to 6 places. Several check calculations were made using the tables and results checked against values obtained using logarithms as outlined above. In every case the results checked satisfactorily.

Acknowledgment

The writer wishes to express appreciation to the Tide Water Associated-Seaboard partnership for permission to publish this material and to J. C. Dennis and O. F. Thornton for their valuable suggestions and criticism during the preparation of the article.

☆ ☆ ☆

Smell those rats burning . . . Mr. Operator!

Just think of those thousands of electric motors spinning away at millions of revolutions per day... Pumping thousands of barrels of precious oil from the ground; and turning the drill pipe on many wildcat wells; and clocking up new performance records in refineries and synthetic rubber factories; and sending millions of barrels of oil surging through a nationwide network of pipe lines...

All of which keep Uncle Sam's forces moving forward toward the victory goal on every front.

Just dwell on this gigantic picture of production and activity within your own industry and you can actually *smell those rats burning*—and you know the rats we mean.

Some day in the not-too-far-off, they'll singe. In the meantime, Mr. Operator, let's do everything to safeguard our supply of Utility Electric Power, and to keep all power equipment in efficient operating condition.

There's a bounty on certain rats, and it's up to us to help bag 'em!

SAFEGUARD YOUR MOTORS!

- Establish a dated maintenance schedule.
- Check clearance, bearings, contact fingers, control equipment, and oil in distribution transformer.
- Check air gap and varnish coils.
- Keep worn out parts for exchange on new purchases.

Use Utility Electric Power!

PETROLEUM ELECTRIC POWER ASSOCIATION

Box 1498, Oklahoma City, Oklahoma

Casting Lugs on Ends of Wire Rope

PETROLEUM ENGINEER Exclusive Feature

☆ Practice serves numerous useful purposes in industrial plants

by C. R. Hochmuth

Assistant Works Manager, Kearney and Trecker Corporation

THE practice of casting a lug of solder onto the ends of many of the wire ropes has been adopted in the factory with which the writer is connected. The only exceptions are some of the hoist ropes, which are ended in a basket-type socket, and some of the slings in which the end of the rope is spliced into the rope body to form an eye or bight.

The soldered lug serves several purposes: First, it eliminates the exposed ends of the wires, which are a source of injury and infection to riggers and others handling the rope. Second, it serves as a means for readily attaching hoist ropes to the drums of overhead traveling cranes. Third, when ropes are fastened by clips, the lug on the rope end provides an additional safety feature inasmuch as should slippage of the rope occur the last clip will catch the lug and hold the rope.

Because of its ease of handling, lack of tendency to fly apart, and its resistance to fatigue, preformed rope is being used throughout our plant for crane and hoist ropes and for many of our slings. As this rope requires no seizing at the ends to hold the strands in position, it lends itself better to the casting of solder lugs on the ends. For this purpose we have made some split molds of steel, similar to the one shown in the sketch. These molds are provided for all the sizes of rope we use. The two sections of each mold are held together by means of two screws passing through one section of the mold and into the other section.

To prepare the end of the rope, the strands are unlayed for about an inch and the hemp center is cut back the same distance. The unlayed strands are then cleaned of lubricant and grime by dipping them into a half-and-half solution of commercial muriatic acid and water. The rope should not be inserted so deep that the acid will get on the hemp center. The strands are then tinned by dipping them into molten solder. It may be necessary to dip in acid and solder several times before a good tinning job is obtained. By bunching the strands together they are passed through the bottom of the mold, and then are spread apart, after which hard solder is poured into the mold. After the solder cools, the screws holding the mold together are removed, allowing the two mold sections to be separated so the rope with the attached lug of solder can be removed.

The edges of the lug are filed slightly round to eliminate sharpness.

When solder lugs are to be applied to ordinary, or non-preformed rope, it is necessary to apply a seizing of soft wire to the rope at a point just below the bottom of the mold, to prevent the strands from raveling. The seizing must be applied before the strands are opened up, and it should be followed by another seizing an inch or so below the first. After the lug is cast, the seizings may be removed.

☆ ☆ ☆

Pouring solder into the mold

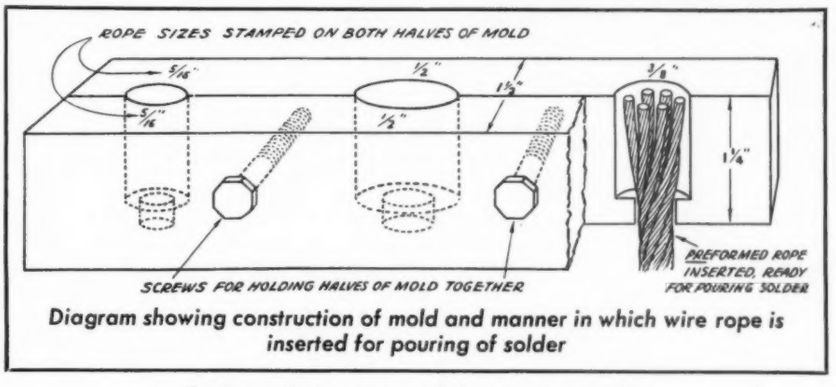


Diagram showing construction of mold and manner in which wire rope is inserted for pouring of solder

Preformed wire rope with lugs cast on ends

Running Tour

WITH MEN IN THE INDUSTRY

JAMES R. HEWITT has been appointed vice-president of the American Manganese Steel Division of The American Brake Shoe and Foundry Company, Chicago, Illinois.

V. F. MICHAEL has resigned as chemistry instructor at Texas A. and I. College, Kingsville, Texas, to become a research engineer for Stanolind Oil and Gas Company at Tulsa, Oklahoma. He will do research on hydrocarbons and their conversion to synthetic products and the utilization of these products in synthetic rubber, plastics, and other essential war products.

W. R. BARNEY, production expediter for W. C. Norris Manufacturer, Inc., and holder of a number of patents on oilfield equipment, died recently in Tulsa, Oklahoma. He was first employed by the Norris company at Tiona, Pennsylvania, in 1903, and was associated with it continuously except for a few years during which he was engaged in professional baseball and private business.

PAUL M. PHILLIPPI, geologist and laboratory technician for the Olean Petroleum Company, Olean, New York, has resigned to join the staff of the Forest Oil Corporation, Bradford, Pennsylvania.

MICHAEL H. DONAHUE, wire chief in the Oil City, Pennsylvania, office of the Northern Pipe Line Company, has retired after serving 36 years with the company.

PAUL DYER MERICA, vice-president of the International Nickel Company, has been elected to honorary membership in the American Institute of Mining and Metallurgical Engineers "for his outstanding leadership in physical metallurgy; for his contributions to the improvement of ferrous and non-ferrous alloys, both through invention and practical development; and for his distinguished and devoted services to this Institute."

B. P. WALTS, district engineer at Delaware, Oklahoma, for Sinclair Prairie Oil Company, has been transferred to Tulsa and placed in the purchasing department.

A. S. RHEA, engineer at Kilgore, Texas, for Sun Oil Company, has been transferred to the Corpus Christi area.

HARRY SCHALLER, who has been employed in the Valuation Department of the Cities Service Gas Company, Bartlesville, Oklahoma, has been transferred to the Ponca City refinery to become power plant foreman. W. L. WALKER, who has been in charge of the power plant for the last few months, will assist in various special engineering studies in the Maintenance and Construction Department.

W. A. FISHER, assistant manager of the Empire Pipeline Company and the Storage Division of Cities Service Oil Company, has accepted a temporary assignment with the Transportation Division of the Office of Petroleum Administration for War in Washington, D. C. Fisher's duties will be assumed by HARRY NELSON, general superintendent. P. O. TETER, assistant general superintendent, will take over Nelson's duties, and J. W. FAGAN, district superintendent at Gladewater, Texas, is being moved to Bartlesville to assume the present duties of Teter. J. P. MCINERNEY, formerly assistant district superintendent at Oklahoma City, will replace Fagan at Gladewater.

A. T. WHITE recently became a partner in the firm of B. and R. Redwood, consulting petroleum technologists and analysts of London, England. White joined the firm 23 years ago upon graduating from college and in 1930 was appointed chief chemist.

RALPH DAMP, who has been manager of Carter Oil Company's Eastern Division, with headquarters at Mattoon, Illinois, has been made manager of the company's Northern Division and will make Cut Bank, Montana, his headquarters.

L. H. DIAL has been made superintendent of the East Texas Salt Water Disposal Company. He has been assistant superintendent. His headquarters will be in Kilgore, Texas.

G. D. PUTNAM, geologist for the Lario Oil and Gas Company at Wichita, Kansas, has been transferred to Midland, Texas.

C. R. BICKEL, manager of the Kansas Division of Shell Oil Company, Inc., Wichita, will become Eastern Division manager March 1 and will make his headquarters at Centralia, Illinois. E. W. CLARK, Tulsa, manager of the Oklahoma Division, will succeed Bickel, and E. E. DAVIS, Mid-Continent drilling superintendent, will retain that position and also assume the duties of Oklahoma Division manager.

L. S. WRIGHT, superintendent at McPherson, Kansas, for the Globe Oil and Refining Company, is now making his headquarters at Zionsville, Indiana.

CHARLES A. DILLARD, superintendent for the Carter Oil Company at Plaquemine, Louisiana, has been transferred to Magnolia, Arkansas.

P. S. NOLAND has been made production geologist for Skelly Oil Company for the West Texas-New Mexico Division, making his headquarters at Midland, Texas. He has been a scout for the company in that area, and previously was production geologist in Oklahoma and North Texas.

W. M. KENDRICK, Humble Oil and Refining Company, Natural Gas Division, has been transferred from Tomball to Pledger, Texas, where he is district chief clerk.

W. J. OVERTON recently was made superintendent of personnel and director of safety for Hinderliter Tool Company, Tulsa, Oklahoma. He has been secretary - manager of the Engineers Club of Tulsa for the last three years.

W. C. CLEMONS, assistant production superintendent for Gulf Oil Corporation, has been promoted to production superintendent. His headquarters are in Houston, Texas.

PHIL K. COCHRAN, division geologist at Shreveport, Louisiana, for The Carter Oil Company, recently was made assistant division superintendent. R. W. BECK has been transferred to Shreveport from Mattoon, Illinois, to become assistant division geologist.

WALTER G. L. SMITH, president of Grizzly Manufacturing Company, Los Angeles, California, recently made an extended business trip to Washington and various eastern manufacturing centers, in connection with the company's increased activities in the production of rubber products for aviation and industrial purposes. He spent several weeks in the eastern territory and at the company's new manufacturing plant in Paulding, Ohio; stopping for brief visits at their Mid-Continent and Gulf Coast branches on the return trip.

GEORGE A. HILL, JR., president of Houston Oil Company of Texas, Houston, has been appointed chairman of the Petroleum Industry War Council's committee on protection of petroleum facilities, WILLIAM R. BOYD, JR., Council chairman, has announced.

The committee, with regional subcommittees in districts of the country corresponding to the various Army Corps areas, is actively working to correlate the activities of the many governmental agencies that have supervision of various elements of the protection of the oil industry's essential war facilities.

Hill succeeds the late WILLIAM S. FARISH, who was chairman of the committee until his death November 29.

DAVID W. HOPKINS, secretary and director of the R-S Products Corporation, Wayne Junction, Philadelphia, Pennsylvania, has been elected vice-president of that corporation. This announcement followed a recent meeting of the board of directors. He will continue in charge of the company's Valve Division.

WM. D. GRAY was elected president of the Westland Oil Corporation at the annual meeting of stockholders, and he and R. J. WOLFE were elected to the board of directors. Offices of the company were moved February 1 from Tulsa, Oklahoma, to Houston, Texas. The new address is 815 Second National Bank Building.

ARTHUR B. GUISE, formerly engaged in fire and safety engineering for the United States Rubber Company, has joined the duGas Engineering Corporation as vice-president in charge of development. Guise graduated from Massachusetts Institute of Technology as a chemical engineer and spent a number of years in development work in the petroleum industry before joining the Factory Mutual Laboratories where he was employed from 1935 until 1941.

WILLIAM J. THOMAS, manager of Mechanical Tube Sales of The Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, has been appointed assistant general sales manager of the company. Thomas, who was formerly with the Process Equipment Division of The Babcock and Wilcox Company at Barberton, Ohio, was transferred to the executive department of the sales offices of The Babcock and Wilcox Tube Company in 1941.

GEORGE VORBE, consulting engineer, Midland, Texas, has accepted a position as associate professor in geology and petroleum engineering at New Mexico School of Mines, Socorro, New Mexico.

PHILIP W. METTLING, compressor expert for The Cooper-Bessemer Corporation and stationed at the Mount Vernon, Ohio, plant for the last several years, has been transferred to the firm's branch office at 640 East 61st Street, Los Angeles, California. In announcing the change, Cooper-Bessemer officials reported that Mettling will continue his work as a compressor calculation engineer. His transfer will bring him in closer contact with the field in that important area, thus expediting the installation, operation, and servicing of Cooper-Bessemer compressors.

M. C. MORGAN, formerly field service engineer, has been appointed assistant Pittsburgh division sales manager of A. M. Byers Company, according to an announcement by M. J. CZARNI-

M. C. MORGAN

ECKI, vice-president in charge of sales. Morgan, who has been with A. M. Byers Company since 1923, will be associated in his new position with H. R. ROWLAND, division manager.

RUSSELL A. WOODALL, assistant district engineer at Shreveport, Louisiana, for United Gas Pipe Line Company, has been promoted to district engineer. J. P. JACKSON, who has been Shreveport district engineer, has been transferred to the general office engineering department.

LEON E. JEANNERET, formerly assistant general sales manager of The Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, has been appointed manager of sales of the Welded Tube Division of The Babcock and Wilcox Company, with general offices and plant at Alliance, Ohio.

EDWARD A. LIVINGSTONE, general sales manager of The Babcock and Wilcox Tube Company at Beaver Falls, will also be general sales manager of The Babcock and Wilcox Company, Welded Tube Division of Alliance.

ROBERT S. SLOAN has been named welding specialist for the Westinghouse Electric and Manufacturing Company in the North Pacific area. Announcement of the appointment was made by K. L. HOWE, Seattle manager for the company. In his new post, Sloan will assist in the application of Westinghouse welding equipment throughout a territory comprising Washington, Oregon, Northern Idaho, and Montana. Sloan joined Westinghouse in 1930 at East Pittsburgh, Pennsylvania, as a graduate student. In 1932 he was transferred to the company's Electric Appliance Division at Mansfield, Ohio, as assistant to the sales promotion manager. In 1933, he was placed in charge of sales training at the Mansfield plant. In 1936, he was transferred to the West Coast, where he served as appliance supervisor at San Francisco and Los Angeles until his recent assignment to the Northwest.

M. M. HELLER, formerly assistant to the superintendent of compressor stations for the United Gas Pipe Line Company, Shreveport, Louisiana, is now a lieutenant in the U. S. Naval Training School, Hollywood, Florida.

HARRY L. MAHONEY, in the rubber industry since 1930, has been named advertising and sales promotion manager of the associated tire and accessory division of The B. F. Goodrich Company, it is announced by F. T. TUCKER, B. F. Goodrich director of advertising. He succeeds F. J. REES, recently made manager of special accounts in the company's associated tire and accessory division.

C. G. PETERSON has been promoted to manager of the control laboratory of Shell Oil Company's refinery at Martinez, California. He has been assistant manager.

JOHN GRIER, drilling superintendent in California for Continental Oil Company, who entered the employ of the company in 1907, has retired from active service.

G. P. COKINOS has been accepted as an Aviation Cadet in the Army Air Force and leaves his duties as petroleum engineer with the Texas Railroad Commission at the Corpus Christi office. He has been with the Commission in the South Texas oil fields for the last two years and had previously worked with the Hamman Exploration Company at Bay City. Cokinos is a petroleum engineering graduate from Texas A. and M. College and is a member of the A. I. M. E. He is the fourth of the four Cokinos brothers, all Aggies, to go into the service.

LAUGH WITH BARNEY

"I'm glad your last customer looked so pleased," said the manager to the sales girl. "What did he want to see?"

"Me, at seven thirty."

"I'd better warn you—my husband will be home in less than an hour."

"But I've done nothing I shouldn't do."

"Well, I just wanted to warn you that if you're going to, you'd better hurry."

"Why does a traffic light turn red?" "You'd turn red too, if you changed in the middle of the street."

Customer: I'd like a dollar dinner, please.

Ritzy Waiter: Yes, sir. On white or rye, sir?

The feminine of bachelor is lady in waiting.

"And what was your husband doing while you were trying to sleep by counting sheep?"

"Pulling the wool over my eyes!"

He: I'm a bank examiner.

She: Well, I'm no bank.

A sweet young thing grabbed a taxi downtown the other day and said to the driver, "To the maternity hospital and never mind rushing. I only work there."

Old Maid: I can't decide between the divan and the arm chair.

Clerk: Lady, you can't make a mistake on a nice comfortable chair like this.

Old Maid: O. K. I'll take the divan.

A couple of colored boys were crouched in a shell hole while a barrage whanged away over their heads. "Look here, Rastus," said one, "ain't you skeert?"

"Not me," boasted the other. "Ain't no shell gonna come along got my name on it."

"Me neither," says the first fellow. "I ain't worried about my name on no shell. What I am worried about is, maybe there's one marked 'To whom it may concern'."

Mother to daughter: I don't want you to marry, I've seen the folly of it.

Daughter: But, mother, I want to see the folly of it, too!

Air raid practice takes up a lot of time but there's no denying it is a great gratification to some of the citizens. "You know," one old maid told another one day last week, "it's the first time a young man has come into my parlor in 20 years and suggested that we put out the light."

The nervous young father registered his wife at the hospital for immediate entrance to the maternity ward and then with deep concern turned to her and asked: "Darling, are you sure now that you want to go through with this?"

Two young ladies were walking down Fifth Avenue. Suddenly one cut loose with a piercing shriek. "Look," she cried in amazement.

"What is so terrible?" asked her friend. "They are only midgets."

"Thank goodness," said the other girl, greatly relieved, "I thought for a minute they were rationing men."

A young man appeared at the country judge's desk and asked for a license.

"What kind of license, son, a hunting license?"

"Nope, I've been hunting long enough. Make it a marriage license."

The stingiest man we ever heard of bought his bride a nickel's worth of peppermint lozenges and took her on a trolley-ride honeymoon. When they got off the car he said, "Honey, suppose we save the rest of this candy for the children."

Handmade sign on cardboard in a little jewelry shop on Wells street, Chicago: "In regard to establishing a woman's army in the United States, I regret that I have but one wife to give to my country.

Husband: Did you finally pay the iceman, dear?

Wife: Yes, yesterday.

Husband: How much did you give him?

Wife: Oh, er—er—about two dollars and something.

Him (meeting her on street): I dreamed about you last night?

Her: Did you?

Him: No. You wouldn't.

Wife: John, dear, I am to be in an amateur theatrical. What would folks say if I were to wear tights?

Hubby: They would probably say that I married you for your money.

Magician (sawing woman in half): Now, ladies and gentlemen, after the young lady is severed, her brains will be given to a medical college and the rest will be thrown to the dogs.

Gallery Gang: Woof, woof, woof!

TAFT

By BILLY MCGRAW
Poet Laureate of The Nomads

On a strip of sunburned desert,
'Tween two rows of barren hills,
Where no brooks go babbling seaward,
Where there are no sparkling rills,
Where the derricks tower skyward,
Like the spars of ocean craft,
Lies a sunbaked desert city,
Lies the oilfield town of Taft.

From the hills of Buena Vista,
One can see within the town,
Stately buildings standing proudly,
Flanked by dwellings bare and brown,
Wretched hovels on the outskirts,
Growing thinner—straggling out,
Fade away into the sage brush,
Spread for miles and miles about.

Poets sing not of its beauties,
Sing no songs of shady lanes,
Nor of dells in land adjacent,
Yet its beauty never wanes.
Beauty that to me is latent,
In its history and its lore,
And to me'll remain in memory,
Beautiful forevermore.

Just a feeling Taft inspires,
Reminiscent of frontiers,
Soothes a longing I inherit,
From ancestral pioneers,
Longing to be on the border,
Where no laws of caste are known,
Where each man works out his problems,
Where the stoutest hearts are grown.

In the Taft I well remember,
Trigger fingers were not slow,
It is now though sane and steady
Still the Taft I used to know.
Oil men, royal too and kindly,
Though without a crest or crown,
Keep my memory always freshened,
Of that desert oilfield town.

Hot as hades in the summer,
When the sun is beating down,
And the heat waves dance and wriggle
O'er the desert bare and brown.
Yet to many olden timers
It is like a cooling draft,
For their hearts are on the desert
In the oilfield town of Taft.

—*Flying Carpet.*

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 68

A VALUABLE and regular feature of *The Petroleum Engineer,* begun six years ago, the Continuous Tables were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

To readers of *The Petroleum Engineer,* who are only now becoming interested in the Continuous Tables, it should be pointed out that each table is assigned a filing or index number that conforms with the Dewey Decimal System of classification as modified and extended for the petroleum and related industries by L. C. Uren, professor of Petroleum Engineering at the University of California. This complete index has been published in earlier installments of the tables and is now available in booklet form at a cost of 50 cents per copy from *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas. Complete sets of the tables from the first installment to the present are also available in conjunction with subscriptions.

INDEX TO TABLES*

Title of Table	*Index No.*	*Page*	*Issue*
Temperature conversion—Centigrade and Fahrenheit	P 061.001.	109	Aug.
Temperature conversion—Centigrade and Fahrenheit (sheet 2)	P 061.001.	131	Nov.
Squares of whole numbers	P 061.001.4	115	Aug.
Vapor pressure chart for volatile hydrocarbons	P 210.0 P 771.0	145	Jan.
Mechanical and physical properties A.P.I. standard drill pipe	P 425.215.	121	Dec.
Weight of dry material added to drilling mud, lb. per gal. (Sp. Gr. of additive=4.50)	P 425.218.43	107	Aug.
Calculation of sucker rod load, stretch, and plunger travel	P 514.541.	157	Oct.
Conversion of wellhead pressures to pressures at base of gas column	P 516.922.005.	141	Nov.
Hydrochloric acid solution schedule (sheet 1)	P 532.911.	103	Aug.
Hydrochloric acid—physical properties of aqueous solution (sheet 2)	P 532.911.	123	Sept.
Hydrochloric acid—physical properties of aqueous solution (sheet 3)	P 532.911.	129	Sept.
Horizontal thermo-siphon heater for oil and gas separators	P 546.32	161	Oct.
Horizontal thermo-siphon heaters for oil field operations (sheet 2)	P 546.32	139	Jan.
Preheating chart for welding (sheet 1)	P 590.6	131	Dec.
Preheating chart for welding (sheet 2)	P 590.6	143	Jan.
Friction loss in oil pipe lines—per 100 ft.	P 615.200.	159	Oct.
Solution of Hazen and Williams formula for small capacity lines	P 615.21	165	Oct.
Solution of Hazen and Williams formula for large capacity lines	P 615.211.	139	Nov.
Pressure-loss conversion chart for pumping fluids	P 615.212.1	119	Feb.
Pipe line arc welding procedures	P 615.222. P 622.24	133	Sept.
Cost per ft. for hauling pipe or casing	P 615.3	127	Sept.
Compressibility chart for natural gases	P 621.	127	Feb.
Solution of Weymouth's Formula for gas flow in large capacity gas lines	P 621.1	113	Aug.
Solution of Weymouth's Formula for gas flow in small high pressure lines	P 621.11	131	Sept.
Pipe line coefficients for gas flow—values of $d^{2.5}$ (sheet 4)	P 622.001.	69	July
Pipe line coefficients for gas flow—values of $d^{2.5}$ (sheet 5)	P 622.001.	73	July
Calculation of pipe sizes, discharge velocities, and loss of head	P 622.1	129	Dec.
Solution of complex pipe line formulas for gas flow	P 622.4	123	Dec.
Dehydration charts for natural gas	P 625.7	125	Feb.
Pump equivalents—gal. per minute	P 670.	105	Aug.
Pump equivalents—gal. per minute (sheet 2)	P 670.	135	Nov.
Pressure extensions—orifice meter calculations (sheet 18)	P 683.32	71	July

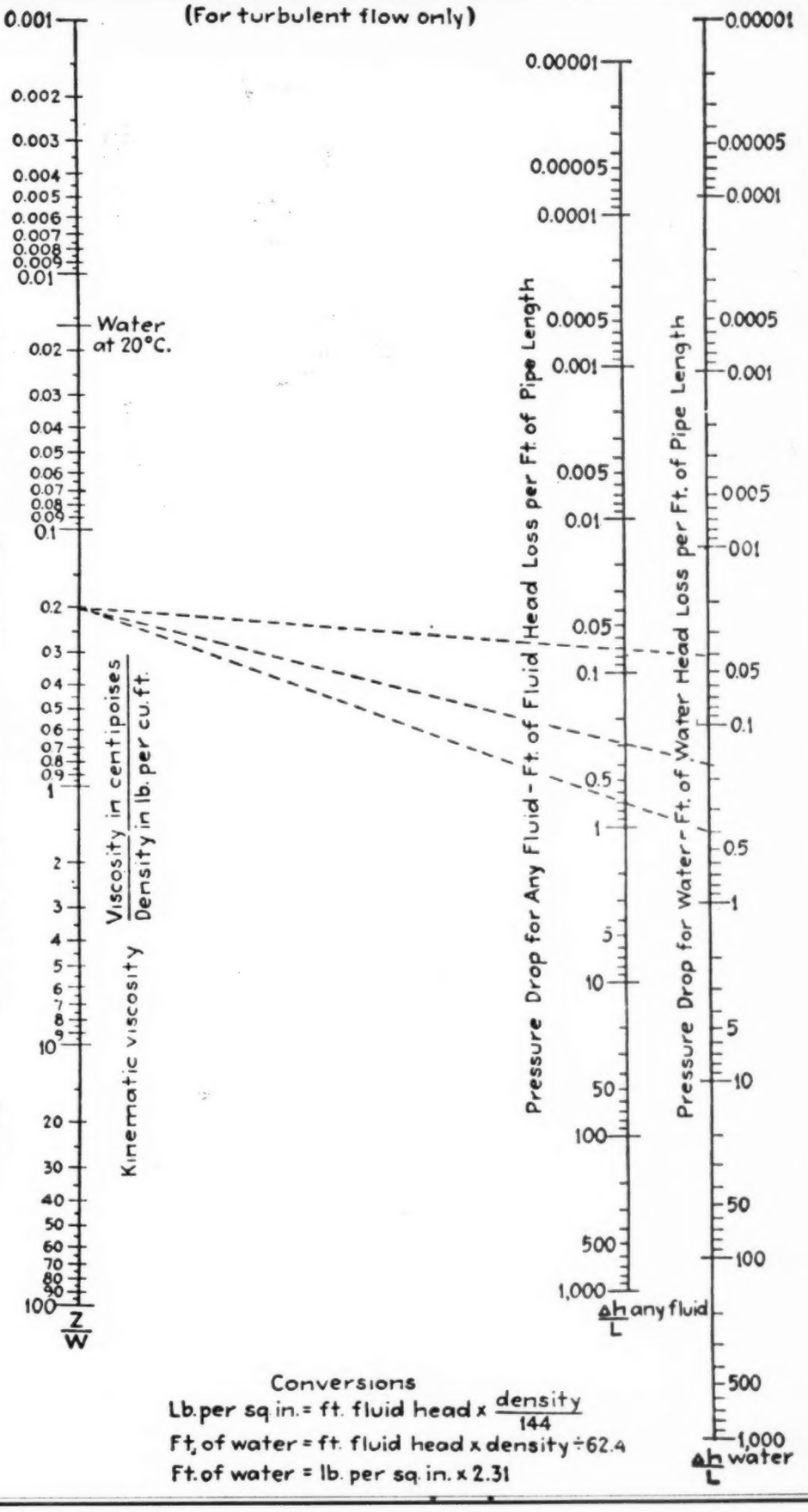
Title of Table		*Index No.*	*Page*	*Issue*
Pressure extensions—orifice meter calculations	(sheet 19)	P 683.32	111	Aug.
Pressure extensions—orifice meter calculations	(sheet 20)	P 683.32	125	Sept.
Pressure extensions—orifice meter calculations	(sheet 21)	P 683.32	155	Oct.
Pressure extensions—orifice meter calculations	(sheet 22)	P 683.32	143	Nov.
Pressure extensions—orifice meter calculations	(sheet 23)	P 683.32	125	Dec.
Pressure extensions—orifice meter calculations	(sheet 24)	P 683.32	135	Jan.
Pressure extensions—orifice meter calculations	(sheet 25)	P 683.32	123	Feb.
24-hour capacity of 4-in. by 1/4-in. orifice plate—flange connections		P 683.320.	163	Oct.
24-hour capacity of 4-in. by 1/2-in. orifice plate—flange connections		P 683.321.	121	Sept.
24-hour capacity of 4-in. by 3/4-in. orifice plate—flange connections		P 683.322.	153	Oct.
24-hour capacity of 4-in. by 1-in. orifice plate—flange connections		P 683.323.	133	Nov.
24-hour capacity of 4-in. by 1 1/4-in. orifice plate—flange connections		P 683.324.	137	Nov.
24-hour capacity of 4-in. by 1 1/2-in. orifice plate—flange connections		P 683.325.	119	Dec.
24-hour capacity of 4-in. by 1 3/4-in. orifice plate—flange connections		P 683.326.	141	Jan.
24-hour capacity of 4-in. by 2-in. orifice plate—flange connections		P 683.327.	137	Jan.
24-hour capacity of 4-in. by 2 1/4-in. orifice plate—flange connections		P 683.328	147	Jan.
24-hour capacity of 4-in. by 2 1/2-in. orifice plate—flange connections		P 683.329.	121	Feb.
24-hour capacity of 4-in. by 2 3/4-in. orifice plate—flange connections		P 683.330.	129	Feb.
Solution of Oliphant's formula for gas flow in vacuum and pressure lines for gasoline plants		P 731.3	127	Dec.
Charts for cooling tower requirements		P 772.4	131	Feb.

*This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941 issue, and 48-60, inclusive in the June, 1942, issue.

INDEX TO ADVERTISERS IN TABLES

		Page	*Issue*	*Backing Table No.*
Air Reduction Co., Inc.		134	Nov.	P 683.323.
American Air Filter Company, Inc.		110	Aug.	P 061.001.
American Air Filter Company, Inc.		128	Dec.	P 731.3
Bantam Bearings Corporation		116	Aug.	P 061.001.4
Bantam Bearings Corporation	(sheet 4)	70	July	P 622.001.
Bantam Bearings Corporation	(sheet 2)	124	Sept.	P 532.911.
Bantam Bearings Corporation		166	Oct.	P 615.21
Bantam Bearings Corporation	(sheet 2)	132	Nov.	P 061.001.
Bantam Bearings Corporation		120	Dec.	P 683.325.
Bantam Bearings Corporation		148	Jan.	P 683.328.
Bantam Bearings Corporation		120	Feb.	P 615.212.1
Chapman Valve Manufacturing Company, The	(sheet 19)	112	Aug.	P 683.32
Chapman Valve Manufacturing Company, The	(sheet 21)	156	Oct.	P 683.32
Chapman Valve Manufacturing Company, The		122	Feb.	P 683.329.
Cleveland Trencher Company, The		142	Jan.	P 683.326.
Cook, C. Lee, Manufacturing Co., Inc.	(sheet 1)	132	Dec.	P 590.6
Crane Co.		160	Oct.	P 615.200.
Cummins Engine Company		138	Nov.	P 683.324.
Dearborn Chemical Company		114	Aug.	P 621.1
Fisher Governor Company	(sheet 20)	126	Sept.	P 683.32
Fisher Governor Company	(sheet 24)	136	Jan.	P 683.32
Graver Tank & Mfg. Co., Inc.		106	Aug.	P 670.
Hazard Wire Rope Division of American Chain and Cable Co., Inc.		122	Sept.	P 683.321.
Hazard Wire Rope Division of American Chain and Cable Co., Inc.	(sheet 2)	140	Jan.	P 546.32
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 1)	104	Aug.	P 532.911.
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 5)	74	July	P 622.001.
Hyatt Bearings Division, General Motors Sales Corporation		134	Sept.	P 615.222. P 622.24
Hyatt Bearings Division, General Motors Sales Corporation		154	Oct.	P 683.322.
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 22)	144	Nov.	P 683.32
Hyatt Bearings Division, General Motors Sales Corporation		130	Dec.	P 622.1
Hyatt Bearings Division, General Motors Sales Corporation		138	Jan.	P 683.327.
Hyatt Bearings Division, General Motors Sales Corporation		132	Feb.	P 625.7
Jones & Laughlin Steel Corporation	(sheet 23)	126	Dec.	P 683.32
Jones & Laughlin Steel Corporation		130	Feb.	P 683.330.
LeRoi Company		108	Aug.	P 425.218.43
LeRoi Company		158	Oct.	P 514.541.
LeRoi Company		142	Nov.	P 516.922.005.
Linde Air Products Company, The		124	Dec.	P 622.4
Page Steel & Wire Division of American Chain and Cable Co., Inc.	(Sheet 25)	124	Feb.	P 683.32
Pritchard, J. F., and Company		126	Feb.	P 621.
Ridge Tool Company		162	Oct.	P 546.32
Ridge Tool Company	(sheet 2)	144	Jan.	P 590.6
Twin Disc Clutch Company	(sheet 2)	136	Nov.	P 670.
Twin Disc Clutch Company		128	Feb.	P 772.4
Universal Atlas Cement Corporation	(sheet 3)	130	Sept.	P 532.911.
Universal Atlas Cement Corporation		122	Dec.	P 425.215.
Vortox Manufacturing Company	(sheet 18)	72	July	P 683.32
Vortox Manufacturing Company		164	Oct.	P 683.32
Waukesha Motor Company		128	Sept.	P 615.3
Whitney Chain and Manufacturing Company		132	Sept.	P 621.11
Whitney Chain and Manufacturing Company		140	Nov.	P 615.211.
Whitney Chain and Manufacturing Company		146	Jan.	P 210.0 P 771.0

PRESSURE-LOSS CONVERSION CHART FOR PUMPING FLUIDS

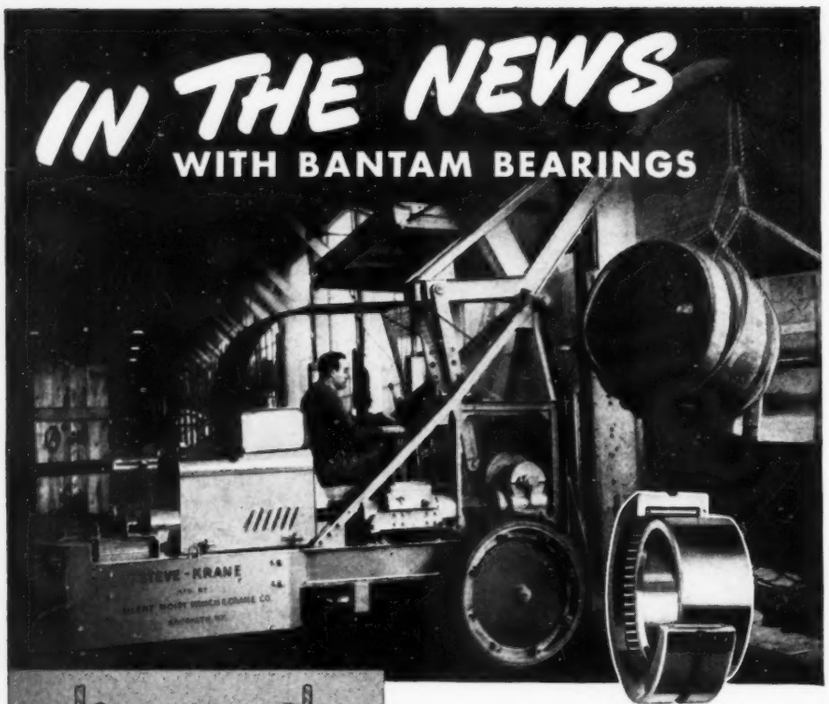

(For turbulent flow only)
Water at 20°C.
Kinematic viscosity = Viscosity in centipoises / Density in lb. per cu. ft.
Z/W
Pressure Drop for Any Fluid - Ft. of Fluid Head Loss per Ft. of Pipe Length
Δh/L any fluid
Pressure Drop for Water - Ft. of Water Head Loss per Ft. of Pipe Length
Δh/L water
Conversions
Lb. per sq. in. = ft. fluid head x density / 144
Ft. of water = ft. fluid head x density ÷ 62.4
Ft. of water = lb. per sq. in. x 2.31

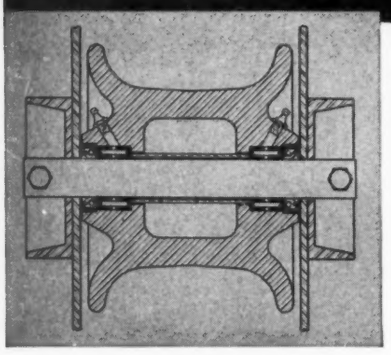
Among the most convenient ways of calculating the friction loss in a pipe for a liquid other than water is to determine the friction loss with water and then convert to the loss with the liquid actually flowing in the pipe. Numerous handbooks and tables give the friction loss for water in various types and sizes of pipe and various rates of flow.

In converting friction loss with water to the friction loss of the liquid being piped, the absolute viscosity of the liquid at the average flowing temperature must be known and its specific weight. The kinematic viscosity may then be found and the friction loss converted from that of water under the same conditions.

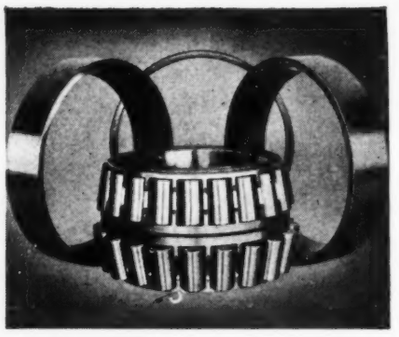
Reproduced by permission of *Chemical and Metallurgical Engineering*, January, 1943, from article by W. E. Pratt, Worthington Pump and Machinery Corporation.

IN THE NEWS
WITH BANTAM BEARINGS

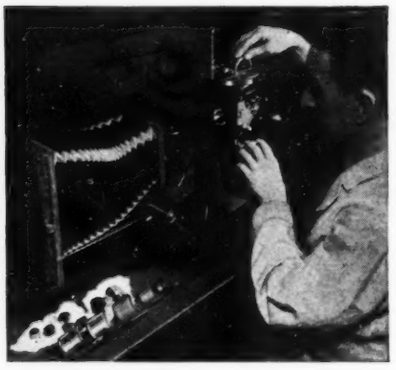




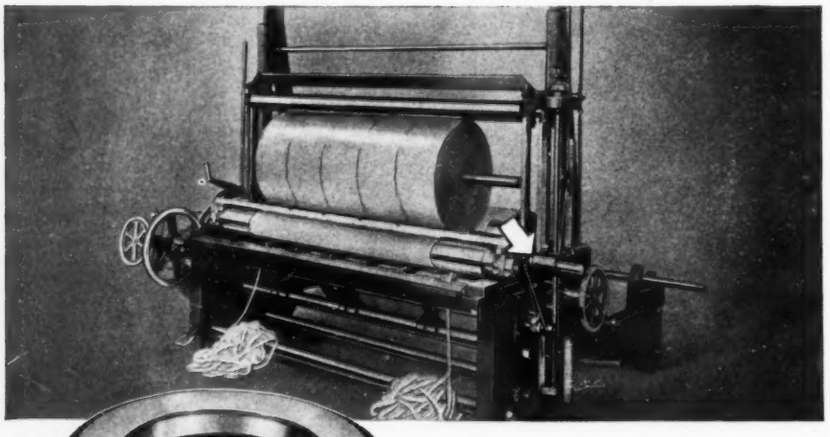
MECHANICAL "STEVEDORES" like this 5-ton STEVE-KRANE built by Silent Hoist Winch & Crane Co. are playing an important part in speeding the loading of goods and equipment for distant fronts. And Bantam Quill Bearings on the boom sheaves and rollers (shown in cross-section view) contribute to the efficiency of these cranes, because of their low coefficient of friction, high load capacity, and effective method of lubrication—while their unit construction facilitates assembly. For full details on these compact anti-friction bearings, write for Bulletin P-104.



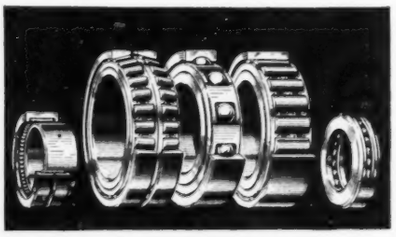
38" O.D., 21" I.D., 19½" LONG, this two-row tapered roller bearing for steel mill service is a typical instance of Bantam's skill in the design and manufacture of large bearings for special jobs. To meet the needs of America at war, Bantam today is manufacturing some of the largest anti-friction bearings ever built.



METALLURGICAL CHECK-UP is a regular part of Bantam inspection on bearings of all types. Here the grain structure of rollers and races is undergoing microscopic examination to assure conformity to metallurgical specifications.



FAST, ACCURATE SLITTING of paper is the job of the Camachine 8, Model 10, product of Cameron Machine Company. Among the factors in the popularity of this machine in paper mill finishing rooms and converting plants is the use of Bantam Ball Thrust Bearings.



ENGINEERING COUNSEL based on the design and application of straight roller, tapered roller, needle, and ball bearings is a vital phase of Bantam's service to industry. If you are seeking competent advice on your anti-friction bearing problems, TURN TO BANTAM.

ARMY E NAVY

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION · SOUTH BEND · INDIANA

SUBSIDIARY OF THE TORRINGTON COMPANY · TORRINGTON, CONN.

24-HOUR CAPACITY* OF 4-IN. BY 2½-IN. ORIFICE PLATE—FLANGE CONNECTION

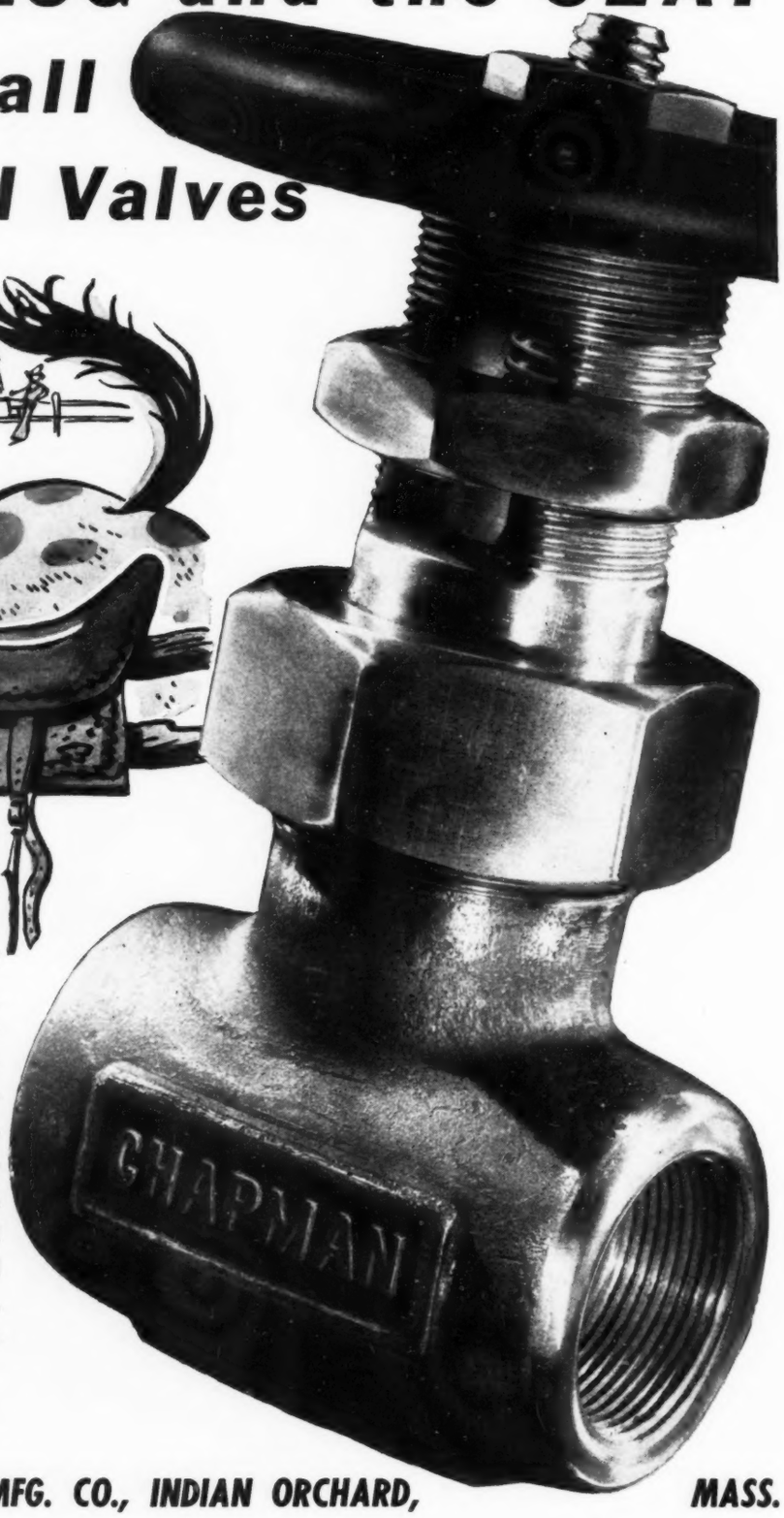
Pressure, lb. per sq. in. ga.	Differential, in. of water										
	5	10	20	30	40	50	60	70	80	90	100
10	483	679	962	1180	1359	1520	1668	1798	1925	2042	2151
20	627	810	1141	1398	1616	1807	1977	2138	2286	2421	2556
30	649	919	1298	1589	1833	2051	2247	2430	2595	2752	2900
40	719	1015	1437	1759	2034	2273	2486	2687	2874	3048	3214
50	779	1106	1563	1916	2212	2473	2709	2922	3127	3323	3497
60	840	1189	1681	2055	2378	2656	2909	3144	3362	3562	3758
70	893	1267	1790	2190	2530	2830	3100	3349	3579	3797	4002
80	945	1337	1894	2317	2678	2992	3279	3540	3784	4015	4233
90	997	1407	1990	2439	2813	3148	3449	3723	3980	4220	4450
100	1041	1472	2081	2552	2948	3292	3610	3897	4167	4420	4659
110	1084	1537	2173	2661	3070	3436	3762	4063	4346	4706	4855
120	1128	1598	2260	2765	3192	3571	3910	4224	4516	4790	5047
130	1171	1655	2338	2865	3309	3701	4054	4376	4681	4964	5234
140	1215	1711	2421	2965	3423	3328	4193	4529	4838	5134	5413
150	1250	1768	2495	3057	3532	3950	4324	4672	4995	5295	5583
160	1285	1820	2574	3148	3636	4067	4455	4812	5143	5456	5752
170	1319	1868	2643	3240	3741	4180	4581	4947	5291	5609	5913
180	1359	1920	2717	3327	3841	4294	4703	5082	5430	5761	6070
190	1393	1968	2783	3410	3937	4402	4820	5208	5569	5905	6227
200	1424	2016	2852	3492	4032	4507	4938	5334	5704	6048	6375
210	1459	2064	2918	3575	4124	4611	5051	5456	5835	6188	6523
220	1489	2108	2983	3653	4215	4716	5165	5578	5961	6323	6667
230	1524	2151	3044	3728	4307	4812	5273	5696	6088	6458	6806
240	1555	2195	3105	3806	4394	4912	5378	5809	6214	6588	6946
250	1585	2238	3166	3880	4476	5008	5487	5922	6332	6719	7081
260	1611	2282	3227	3950	4564	5099	5587	6035	6453	6841	7216
270	1642	2321	3283	4024	4646	5191	5687	6144	6567	6967	7342
280	1672	2365	3340	4093	4725	5282	5787	6253	6684	7089	7472
290	1698	2404	3397	4163	4803	5374	5883	6358	6797	7207	7599
300	1729	2443	3453	4228	4881	5461	5979	6462	6906	7324	7721
310	1755	2482	3510	4298	4960	5548	6075	6562	7015	7442	7843
320	1781	2517	3562	4363	5038	5630	6166	6662	7124	7555	7964
330	1807	2556	3614	4424	5112	5713	6258	6763	7229	7668	8082
340	1833	2591	3667	4490	5186	5796	6349	6858	7333	7777	8200
350	1859	2630	3719	4555	5256	5879	6440	6954	7433	7886	8313
360	1886	2665	3767	4616	5330	5957	6527	7050	7538	7995	8426
370	1907	2700	3819	4677	5400	6035	3615	7141	7638	8099	9539
380	1933	2735	3867	4738	5469	6114	6697	7237	7734	8204	8648
390	1960	2770	3915	4794	5539	6192	6734	7324	7834	8309	8757
400	1981	2804	3963	4855	5504	6266	6867	7416	7930	8409	8866
410	2007	2839	4011	4912	5674	6345	6950	7507	8025	8509	8970
420	2029	2870	4058	4973	5739	6419	7028	7594	8117	8609	9075
430	2051	2904	4106	5030	5805	6493	7111	7681	8213	8709	9179
440	2077	2935	4150	5086	5870	6562	7189	7764	8304	8805	9284
450	2099	2970	4198	5138	5935	6636	7268	7851	8391	8901	9384
460	2121	3000	4241	5195	6001	6706	7346	7934	8483	8997	9484
470	2142	3031	4285	5247	6062	6776	7425	8017	8574	9092	9584
480	2164	3061	4328	5304	6123	6845	7499	8099	8648	9184	9685
490	2186	3092	4372	5356	6183	6915	7577	8182	8748	9280	9780
500	2208	3122	4416	5408	6244	6985	7651	8265	8835	9371	9876

4-in. x 2½-in. orifice plate size, flange connection.
*Million cu. ft. based on (4 oz.) 14.4 lb. per sq. in., 0.60 gravity, and 60°F. temperature.

1 hour coefficient = 1814.4
24 hour coefficient = 43545.6

CHAPMAN LIST 960

Has the PLUG and the SEAT to Outrun all other Small Valves



Made extra tough for extra life, this small forged-steel Chapman Gate valve is the one to put your money on, in any endurance contest with similar types of valves. And for especially severe duties, this valve may be fitted with special seats and plugs super-hardened by an exclusive Chapman process *which imparts even longer life.* So play List 960 across the board on every small-valve job . . . *you can't lose.* You can get List 960 with either inside or outside screw, for all pressures up to 750 lb. at 800° F., and cold working pressures to 1500 lb. . . . for all small field and refinery lines from ¼" to 2".

ARMY E NAVY

THE CHAPMAN VALVE MFG. CO., INDIAN ORCHARD, MASS.

Static Press.
3300-3395 lb.

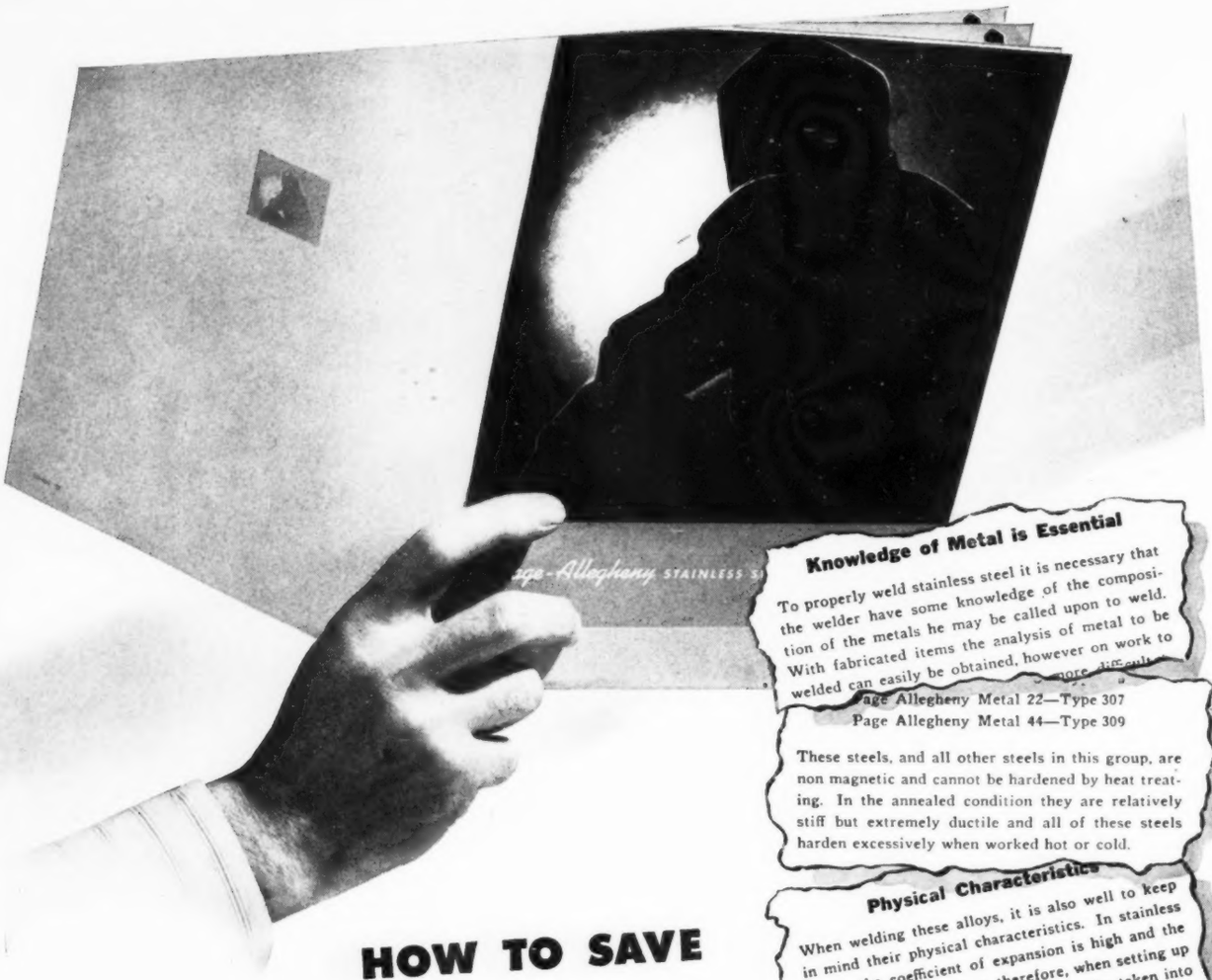
PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure, in. of water	Static pressure, lb. per sq. in. ga.																			
	3300	3305	3310	3315	3320	3325	3330	3335	3340	3345	3350	3355	3360	3365	3370	3375	3380	3385	3390	3395
2	81.42	81.47	81.53	81.60	81.66	81.72	81.79	81.84	81.90	81.97	82.03	82.08	82.14	82.21	82.27	82.32	82.39	82.45	82.51	82.56
4	115.0	115.1	115.2	115.3	115.4	115.5	115.6	115.7	115.8	115.9	116.0	116.1	116.2	116.3	116.4	116.4	116.5	116.6	116.7	116.8
6	141.0	141.1	141.2	141.3	141.4	141.5	141.6	141.7	141.8	141.9	142.0	142.1	142.2	142.3	142.5	142.6	142.7	142.8	142.9	143.0
8	162.8	162.9	163.1	163.2	163.3	163.4	163.6	163.7	163.8	163.9	164.1	164.2	164.3	164.4	164.5	164.6	164.8	164.9	165.0	165.1
10	182.1	182.2	182.3	182.5	182.6	182.7	182.9	183.0	183.1	183.3	183.4	183.6	183.7	183.8	183.9	184.1	184.2	184.4	184.5	184.6
12	199.5	199.6	199.7	199.9	200.0	200.2	200.4	200.5	200.6	200.8	200.9	201.1	201.2	201.4	201.5	201.7	201.8	201.9	202.1	202.3
14	215.5	215.6	215.8	215.9	216.1	216.3	216.4	216.6	216.7	216.9	217.1	217.2	218.4	217.6	217.7	217.9	218.0	218.2	218.3	218.5
16	230.3	230.5	230.6	230.8	231.0	231.2	231.4	231.5	231.7	231.9	232.0	232.2	232.4	232.6	232.7	232.9	233.1	233.2	233.4	233.6
18	244.3	244.5	244.7	244.9	245.0	245.2	245.4	245.6	245.8	245.9	246.1	246.3	246.5	246.7	246.9	247.0	247.2	247.4	247.6	247.7
20	257.5	257.7	257.9	258.1	258.3	258.4	258.7	258.8	259.0	259.2	259.4	259.6	259.8	260.0	260.2	260.4	260.6	260.8	260.9	261.1
21	263.9	264.1	264.3	264.5	264.7	264.9	265.1	265.3	265.4	265.7	265.9	266.0	266.2	266.5	266.6	266.8	267.1	267.2	267.4	267.6
22	270.1	270.2	270.4	270.7	270.8	271.0	271.3	271.6	271.6	271.9	272.1	272.3	272.4	272.7	272.9	273.1	273.3	273.5	273.7	273.8
23	276.2	276.3	276.5	276.8	276.9	277.2	277.4	277.6	277.8	278.0	278.2	278.4	278.6	278.8	279.0	279.2	279.5	279.6	279.8	280.0
24	282.1	282.3	282.5	282.7	282.9	283.1	283.4	283.6	283.8	283.9	284.2	284.4	284.6	284.8	285.0	285.2	285.5	285.7	285.9	286.1
25	287.9	288.1	288.3	288.6	288.8	288.9	289.2	289.4	289.6	289.8	290.1	290.3	290.5	290.7	290.9	291.1	291.4	291.6	291.8	291.9
26	293.6	293.8	294.0	294.3	294.5	294.7	294.9	295.1	295.3	295.6	295.8	295.9	296.2	296.5	296.7	296.9	297.1	297.3	297.5	297.7
27	299.2	299.4	299.6	299.9	300.1	300.3	300.5	300.7	300.9	301.2	301.4	301.6	301.8	302.1	302.3	302.5	302.8	302.9	303.2	303.4
28	304.7	304.9	305.1	305.4	305.6	305.8	306.1	306.3	306.5	306.8	306.9	307.2	307.4	307.7	307.9	308.1	308.4	308.6	308.8	308.9
29	310.0	310.3	310.5	310.8	310.9	311.2	311.5	311.7	311.9	312.2	312.4	312.6	312.8	313.1	313.3	313.5	313.8	313.9	314.2	314.4
30	315.4	315.6	315.8	316.1	316.3	316.5	316.8	317.0	317.2	317.5	317.7	317.9	318.2	318.4	318.6	318.9	319.1	319.4	319.6	319.8
31	320.6	320.8	321.1	321.3	321.6	321.8	322.1	322.3	322.5	322.8	322.9	323.2	323.4	323.7	323.9	324.2	324.4	324.7	324.9	325.1
32	325.7	325.9	326.2	326.5	326.7	326.9	327.2	327.4	327.7	327.9	328.2	328.4	328.6	328.9	329.1	329.4	329.6	329.9	330.1	330.3
33	330.8	331.0	331.3	331.5	331.8	332.0	332.3	332.5	332.8	333.0	333.3	333.5	333.7	334.0	334.2	334.5	334.8	334.9	335.2	335.5
34	335.7	335.9	336.2	336.5	336.7	336.9	337.3	337.5	337.7	338.0	338.3	338.5	338.7	339.0	339.2	339.5	339.8	340.0	340.2	340.5
35	340.6	340.9	341.1	341.4	341.6	341.9	342.2	342.4	342.7	342.9	343.2	343.4	343.7	343.9	344.2	344.4	344.7	344.9	345.2	345.4
36	345.5	345.7	345.9	346.3	346.5	346.7	347.0	347.3	347.5	347.8	348.1	348.3	348.5	348.8	349.1	349.3	349.6	349.9	350.1	350.3
37	350.3	350.5	350.7	351.0	351.3	351.5	351.8	352.1	352.3	352.6	352.9	353.1	353.4	353.7	353.9	354.2	354.5	354.7	354.9	355.2
38	354.9	355.2	355.4	355.7	355.9	356.2	356.5	356.8	357.0	357.3	357.6	357.8	358.1	358.4	358.6	358.9	359.2	359.4	359.7	359.9
39	359.6	359.8	360.1	360.4	360.6	360.9	361.2	361.5	361.7	362.0	362.3	362.5	362.8	363.1	363.3	363.6	363.9	364.1	364.4	364.6
40	364.2	364.4	364.7	365.0	365.3	365.5	365.8	366.1	366.3	366.6	366.9	367.2	367.4	367.7	367.9	368.2	368.6	368.8	369.1	369.3
41	368.7	368.9	369.2	369.5	369.8	370.0	370.3	370.6	370.9	371.2	371.4	371.7	371.9	372.3	372.5	372.8	373.1	373.4	373.6	373.9
42	373.2	373.4	373.7	374.0	374.3	374.5	374.9	375.1	375.4	375.7	375.9	376.2	376.5	376.8	377.1	377.3	377.6	377.9	378.2	378.4
43	377.6	377.8	378.1	378.4	378.7	378.9	379.3	379.5	379.8	380.1	380.4	380.6	380.9	381.2	381.5	381.7	382.1	382.3	382.6	382.9
44	381.9	382.2	382.5	382.8	383.1	383.3	383.7	383.9	384.2	384.5	384.8	385.0	385.3	385.6	385.9	386.2	386.5	386.8	387.0	387.3
45	386.2	386.5	386.8	387.1	387.4	387.7	387.9	388.3	388.5	388.9	389.1	389.4	389.7	390.0	390.3	390.5	390.9	391.1	391.4	391.7
46	390.5	390.8	391.1	391.4	391.7	391.9	392.3	392.5	392.8	393.2	393.4	393.7	393.9	394.3	394.6	394.8	395.2	395.5	395.7	396.0
47	394.8	395.0	395.3	395.7	395.9	396.2	396.6	396.8	397.1	397.4	397.7	397.9	398.3	398.6	398.9	399.2	399.5	399.8	400.1	400.3
48	398.9	399.2	399.5	399.8	400.1	400.4	400.7	400.9	401.3	401.6	401.9	402.2	402.4	402.8	403.1	403.3	403.7	403.9	404.2	404.5
49	403.1	403.3	403.6	403.9	404.3	404.5	404.9	405.2	405.4	405.8	406.1	406.4	406.6	406.9	407.3	407.5	407.9	408.2	408.5	408.7
50	407.1	407.4	407.7	408.1	408.4	408.6	408.9	409.3	409.6	409.9	410.2	410.5	410.8	411.1	411.4	411.7	412.0	412.3	412.6	412.9
51	411.2	411.5	411.8	412.1	412.4	412.7	413.0	413.3	413.6	413.9	414.2	414.5	414.8	415.2	415.5	415.7	416.1	416.4	416.7	416.9
52	415.2	415.5	415.8	416.1	416.4	416.7	417.1	417.4	417.7	418.0	418.3	418.6	418.9	419.2	419.5	419.8	420.2	420.5	420.8	421.1
53	419.2	419.5	419.8	420.1	420.4	420.7	421.1	421.4	421.7	422.0	422.3	422.6	422.9	423.3	423.6	423.8	424.2	424.5	424.8	425.1
54	423.1	423.4	423.7	424.1	424.3	424.6	425.0	425.3	425.6	425.9	426.3	426.6	426.8	427.2	427.5	427.8	428.2	428.5	428.8	429.0
55	427.0	427.3	427.6	427.9	428.3	428.6	428.9	429.2	429.5	429.9	430.2	430.5	430.8	431.2	431.5	431.8	432.1	432.4	432.7	433.0
56	430.9	431.2	431.5	431.8	432.1	432.4	432.8	433.1	433.4	433.8	434.1	434.4	434.7	435.1	435.4	435.7	436.0	436.3	436.6	436.9
57	434.7	435.0	435.3	435.7	436.0	436.3	436.7	436.9	437.3	437.7	437.9	438.3	438.6	438.9	439.3	439.6	439.9	440.2	440.5	440.8
58	438.5	438.8	439.1	439.5	439.8	440.1	440.5	440.8	441.1	441.5	441.8	442.1	442.4	442.8	443.1	443.4	443.8	444.1	444.4	444.7
59	442.3	442.6	442.9	443.3	443.6	443.9	444.3	444.6	444.9	445.3	445.6	445.9	446.2	446.6	446.9	447.2	447.6	447.9	448.2	448.5
60	446.0	446.3	446.6	447.0	447.3	447.6	448.0	448.3	448.6	449.0	449.3	449.7	449.9	450.4	450.7	450.9	451.4	451.7	451.9	452.3
61	449.7	450.0	450.3	450.7	451.0	451.3	451.7	452.0	452.4	452.7	453.1	453.4	453.7	454.1	454.4	454.7	455.1	455.4	455.7	456.0
62	453.4	453.7	454.0	454.4	454.7	455.0	455.4	455.7	456.1	456.5	456.8	457.1	457.4	457.8	458.1	458.4	458.8	459.1	459.4	459.8
63	457.0	457.3	457.6	458.0	458.4	458.7	459.1	459.4	459.7	460.1	460.4	460.7	461.1	461.5	461.8	462.1	462.5	462.8	463.1	463.4
64	460.6	460.9	461.3	461.7	462.0	462.3	462.7	463.0	463.4	463.8	464.1	464.1	464.7	465.1	465.4	465.8	466.2	466.5	466.8	467.1
65	464.2	464.5	464.9	465.3	465.6	465.9	466.3	466.6	466.9	467.4	467.7	467.9	468.3	468.7	469.0	469.4	469.8	470.1	470.4	470.7
66	467.8	468.1	468.4	468.8	469.2	469.5	469.9	470.2	470.5	470.9	471.3	471.6	471.9	472.3	472.7	472.9	473.4	474.7	474.0	474.4
67	471.3	471.6	471.9	472.4	472.7	473.0	473.4	473.7	474.1	474.5	474.8	475.1	475.5	475.9	476.2	476.5	476.9	477.3	477.6	477.9
68	474.8	475.1	476.5	475.9	476.2	476.5	476.9	477.3	477.6	478.0	478.4	478.7	479.0	479.4	479.8	480.9	480.5	480.8	481.2	481.5
69	478.3	478.6	478.9	479.4	479.7	480.1	480.5	480.8	481.1	481.6	481.9	482.2	482.6	482.9	483.3	483.6	484.0	484.4	484.7	485.0
70	481.8	482.1	482.4	482.9	483.2	483.5	483.9	484.3	484.6	485.0	485.4	485.7	486.0	486.5	486.8	487.1	487.5	487.9	488.2	488.5
71	485.2	485.5	485.8	486.3	486.6	486.9	487.4	487.7	488.0	488.5	488.8	489.1	489.5	489.9	490.2	490.6	490.9	491.3	491.7	491.9
72	488.6	488.9	489.2	489.7	490.0	490.3	490.8	491.1	491.5	491.9	492.2	492.6	492.9	493.3	493.7	493.9	494.4	494.8	495.1	495.4
73	491.9	492.3	492.6	493.1	493.4	493.8	494.2	494.5	494.9	495.3	495.6	495.9	496.3	496.7	497.1	497.4	497.9	498.2	498.5	498.9
74	495.3	495.6	495.9	496.4	496.8	497.1	497.5	497.9	498.2	498.7	499.0	499.3	499.7	500.1	500.5	500.8	501.2	501.6	501.9	502.3
75	498.6	498.9	499.3	499.8	500.1	500.5	500.9	501.2	501.6	502.0	502.4	502.7	503.1	503.5	503.8	504.2	504.6	504.9	505.3	505.7
76	501.9	502.3	502.7	503.1	503.5	503.8	504.2	504.6	504.9	505.4	505.7	506.1	506.4	506.9	507.2	507.6	507.9	508.3	508.7	509.0
77	505.3	505.6	505.9	506.4	506.8	507.1	507.5	507.9	508.2	508.7	509.0	509.4	509.7	510.2	510.5	510.9	511.3	511.7	512.0	512.4
78	508.5	508.9	509.3	509.7	510.0	510.4	510.8	511.2	511.5	511.9	512.3	512.6	513.1	513.5	513.8	514.2	514.6	514.9	515.3	515.7
79	511.8	512.1	512.5	512.9	513.3	513.6	514.1	514.4	514.8	515.2	515.6	515.9	516.3	516.7	517.1	517.5	517.9	518.3	518.6	518.9
80	514.9	514.4	515.7	516.2	516.5	516.9	517.3	517.7	518.0	518.5	518.8	519.2	519.6	520.0	520.4	520.7	521.2	521.5	521.9	522.2
82	521.4	521.7	522.1	522.6	522.9	523.3	523.7	524.1	524.5	524.9	525.3	525.6	526.0	526.5	526.8	527.2	527.6	527.9	528.4	528.7
84	527.7	528.1	528.5	528.9	529.3	529.6	530.1	530.5	530.8	531.3	531.7	532.0	532.4	532.9	533.2	533.6	534.0	534.4	534.8	535.1
86	533.9	534.4	534.7	535.2	535.6	535.9	536.4	536.8	547.2	537.6	537.9	538.4	538.7	539.2	539.6	539.9	540.4	540.8	541.1	541.5
88	540.2	540.2	540.9	541.4	541.8	542.1	542.6	542.8	543.3	543.8	544.2	544.6	544.9	545.4	545.8	546.2	546.6	547.0	547.4	547.8
90	546.3	546.6	547.0	547.5	547.8	548.3	548.7	549.1	549.5	549.9	550.3	550.7	551.1	551.6	551.9	552.3	552.8	553.2	553.6	553.9
92	552.3	552.7	553.1	553.6	553.9	554.3	554.8	555.2	555.6	556.0	556.0	556.8	557.2	557.7	558.1	558.4	558.9	559.3	559.7	560.1
94	558.2	558.6	559.0	559.5	559.5	560.3	560.8	561.1	561.5	562.0	562.4	562.8	563.2	563.7	564.1	564.4	564.9	565.3	565.7	566.1
96	564.2	564.6	564.9	565.4	565.8	566.2	566.7	567.1	567.5	567.9	568.4	568.8	569.2	569.7	570.0	570.4	570.9	571.3	571.7	572.1
98	569.9	570.4	570.8	571.3	571.7	572.1	572.6	572.9	573.4	573.8	574.2	574.6	575.0	575.5	575.5	576.3	576.8	577.2	577.6	578.0
100	575.8	576.2	576.6	577.1	577.5	577.9	578.4	578.8	569.2	579.7	580.1	580.5	580.9	581.4	581.8	582.2	582.7	483.1	583.5	583.9

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.

Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.

Table has been condensed to serve field men in approximating meter readings, intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.



Knowledge of Metal is Essential

To properly weld stainless steel it is necessary that the welder have some knowledge of the composition of the metals he may be called upon to weld. With fabricated items the analysis of metal to be welded can easily be obtained, however on work to

Page Allegheny Metal 22—Type 307
Page Allegheny Metal 44—Type 309

These steels, and all other steels in this group, are non magnetic and cannot be hardened by heat treating. In the annealed condition they are relatively stiff but extremely ductile and all of these steels harden excessively when worked hot or cold.

Physical Characteristics

When welding these alloys, it is also well to keep in mind their physical characteristics. In stainless steels, the coefficient of expansion is high and the heat conductivity is low, therefore, when setting up a job for welding these factors must be taken into account and allowance made for expansion and con-

STANDARD GRADES

The following list shows standard grades of stainless steels. Those which are not included in the standard classif on special order.

GRADE	TYPE NO.	CARBON	CHROME	
Allegheny 17-7	301X	.10-.20	16.00-18.00	
Allegheny "C"	302	Over .08-.20	17.00-19.00	
	302B	Over .08-.20	17.00-19.00	
Allegheny Metal F.M.*	303	.20 max.	17.00-19.00	7
Allegheny "A"	304	.11 max.	17.00-19.00	7
Allegheny "B"	305	Over .05-.20	18.00-20.00	
Allegheny "B" Spec.	306	.11 max.	18.00-20.00	
Allegheny 22		Over .08-.20	19.00-22.00	

HOW TO SAVE TIME AND MATERIAL WELDING *Stainless Steel*

★ This booklet will help you. You can get a copy by asking your local PAGE Distributor or writing us direct at the mill in Monessen.

It gives needed data on 42 Commercial Stainless Steels—analyses; physical characteristics; reaction to heat and to cold working; specific welding electrodes to use with each; correct amperage and voltage; polarity; length of arc; direction of arc; starting the weld; preventing undercutting, etc., etc.

A copy of this well illustrated booklet will be sent gladly as soon as your request is received.

PAGE-ALLEGHENY STAINLESS STEEL ELECTRODES

CHROMIUM 18.
NICKEL 8.
CARBON .07 Max.
with COLUMBIUM
SIZE WEIGHT POUNDS NET

PAGE-ALLEGHENY 18-8 ELECTRODES with COLUMBIUM

Base metal and coating balanced to form weld metal of the following chemical composition: Carbon .07% Maximum. Chromium 18% Minimum. Nickel 8% Minimum with Columbium

Recommended for welding all grades of Stainless Steel in which the chrome and nickel

PAGE-ALLEGHENY STAINLESS STEEL ELECTRODES

CHROMIUM 19.
NICKEL 9.
CARBON .07 Max.
SIZE WEIGHT POUNDS NET

PAGE-ALLEGHENY 19-9 ELECTRODES

Base metal and coating balanced to form weld metal of the following chemical composition: Carbon .07% Maximum. Chromium 19% Minimum. Nickel 9% Minimum.

Recommended for welding all grades of stainless steel in which the Chrome and Nickel content is not in excess of 19% and 9% respectively

PAGE WELDING ELECTRODES

PAGE STEEL AND WIRE DIVISION • MONESSEN, PA., ATLANTA, CHICAGO, NEW YORK, PITTSBURGH, SAN FRANCISCO

AMERICAN CHAIN & CABLE COMPANY, Inc.
BRIDGEPORT • CONNECTICUT

DEHYDRATION CHARTS FOR NATURAL GAS

The charts of this table are for the purpose of aiding in hydrate calculations — formation temperature and pressure.

Fig. 1 is a plot of the variation, with pressure, of the temperature at which actual hydrates form and decompose or melt. The curve is algebraically equivalent to the equation

$$T = 8.9\ X^{0.285}$$

Where:

T = forming temperature in °F., and

X = absolute pressure in lb. per sq. in.

Theoretically the water-vapor content of a gas is dependent only on actual volume and temperature; however, when considered on the usual M cu. ft. basis, several corrections are necessary and have been taken care of in Fig. 2. The solid lines are for different pipe-line pressures and can be used to interpolate for pressures not plotted. The dotted line is the theoretical value (the same for all line pressures) for a mixture of perfect gases. As the error it introduces is not conservative, it is of little value.

Charts after E. G. Hammerschmidt, Texoma Natural Gas Company.

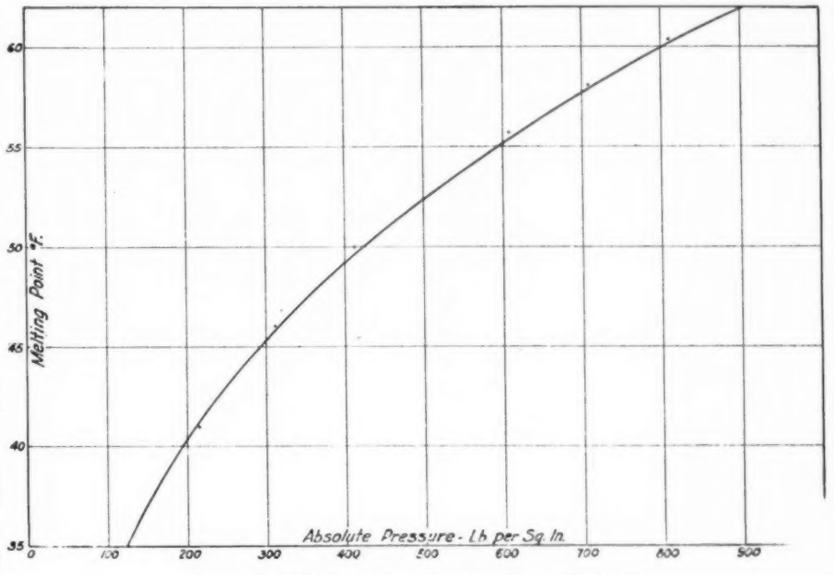
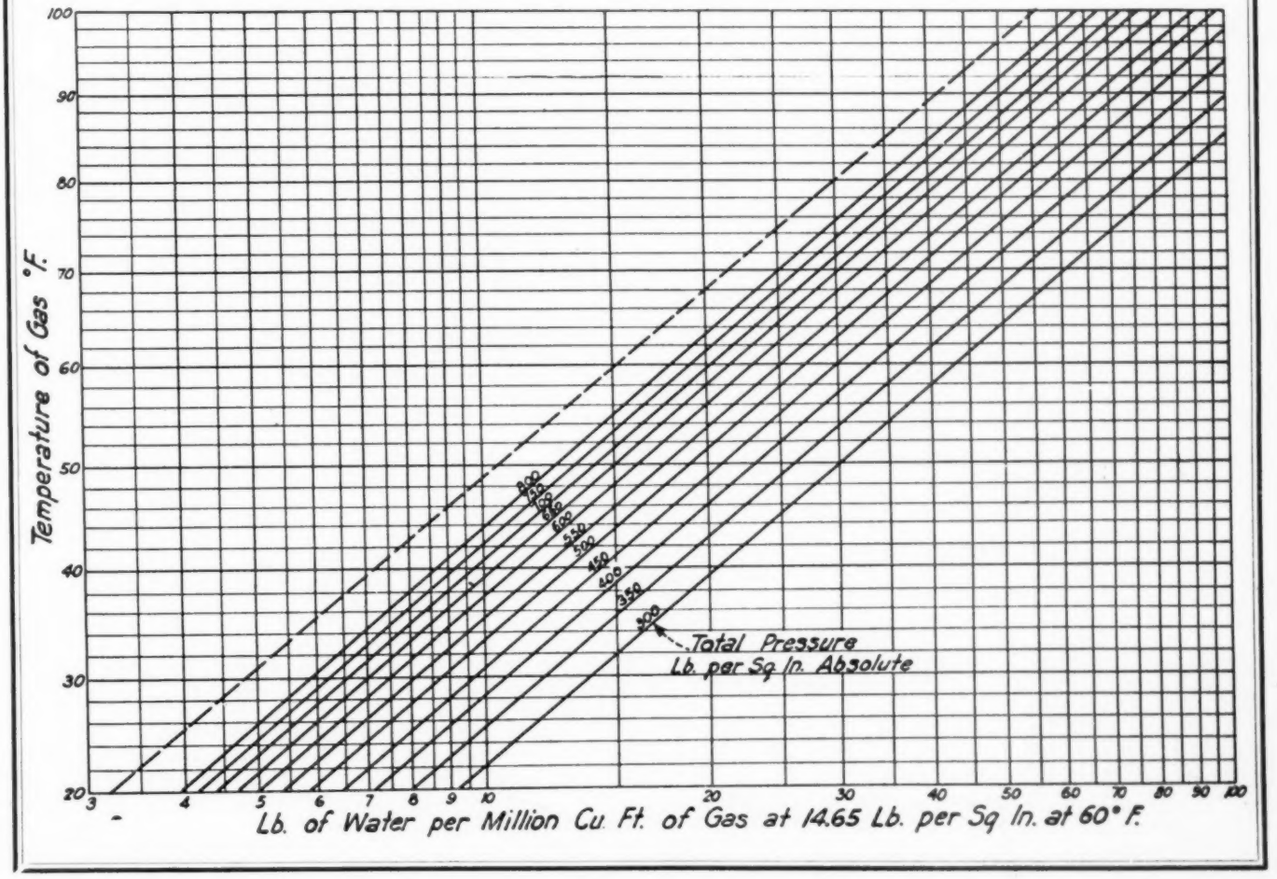
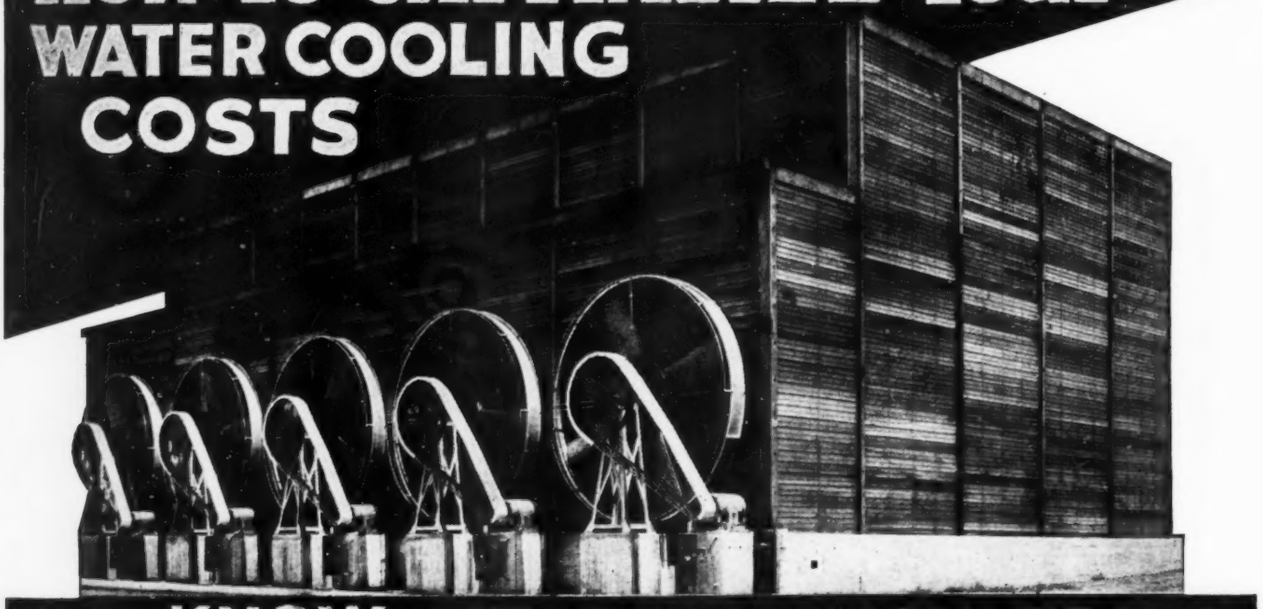


Fig. 2. Melting point of natural gas hydrates

Fig. 1. Pounds of water per million cu. ft. of gas at various temperatures and pressures



How To CAPITALIZE Your WATER COOLING COSTS



AND KNOW WHOSE MECHANICAL DRAFT EQUIPMENT WILL SAVE YOU MOST . . .

Why Pritchard Towers Save You Money

1. Low Pumping Head. Closed pipe water distribution through gravity sprinklers cuts down frictional resistance; saves pump power for lifting; sometimes even permits building higher towers without waste.

2. Liberal Size and Rating. Any "skimping" on capacity must be made up by an extra load on fans or tower efficiency will suffer. Pritchard towers are sized and rated to permit low air velocities and consequent lighter fan loads.

3. High Efficiency, Light Weight, Non-Corrosive Monel Fans. Pritchard fans are the heart of Pritchard tower efficiency and economy. Their superior design and construction saves tremendous amounts of horse power over a period of years. Blades have a special twist and taper that gives a steady, uniform air flow through the entire fan opening.

The use of non-corrosive sheet monel over a light, strong framework cuts weight to half that of cast alloy—ends corrosion and pitting troubles. Larger blades, and often fewer of them, move the required volume of air with less fan speed and less fan power. Pritchard fan drive design and fan housing design, particularly in induced draft towers, contribute further to fan efficiency and horsepower economy.

Further details on request. Write for them.

On the basis of 1¢ per kilowat hour, 24 hours per day, 250 days per year, the cost of operating a mechanical draft tower for 5 years is $300 per horsepower. Add to this the cost of your tower and you have your total 5-year cost, exclusive of upkeep.

Pritchard welcomes and urges this method of purchase because almost invariably Pritchard towers capitalize out at lower cost.

There are several reasons why—the most important of which are described in the column to the left. Read these reasons carefully. File them for future reference if you will. And be sure to get definite cost capitalization figures from Pritchard—and from any others you may choose—on the next mechanical draft tower you buy.

J. F. PRITCHARD and COMPANY
FIDELITY BUILDING KANSAS CITY, MO.
Branch Offices in Tulsa, Okla.; Houston, Texas; Atlanta, Ga.
Chicago, Ill.; Pittsburgh, Pa.; New York City

PRITCHARD
Atmospheric and Mechanical Draft
WATER COOLING TOWERS

COMPRESSIBILITY CHART FOR NATURAL GASES

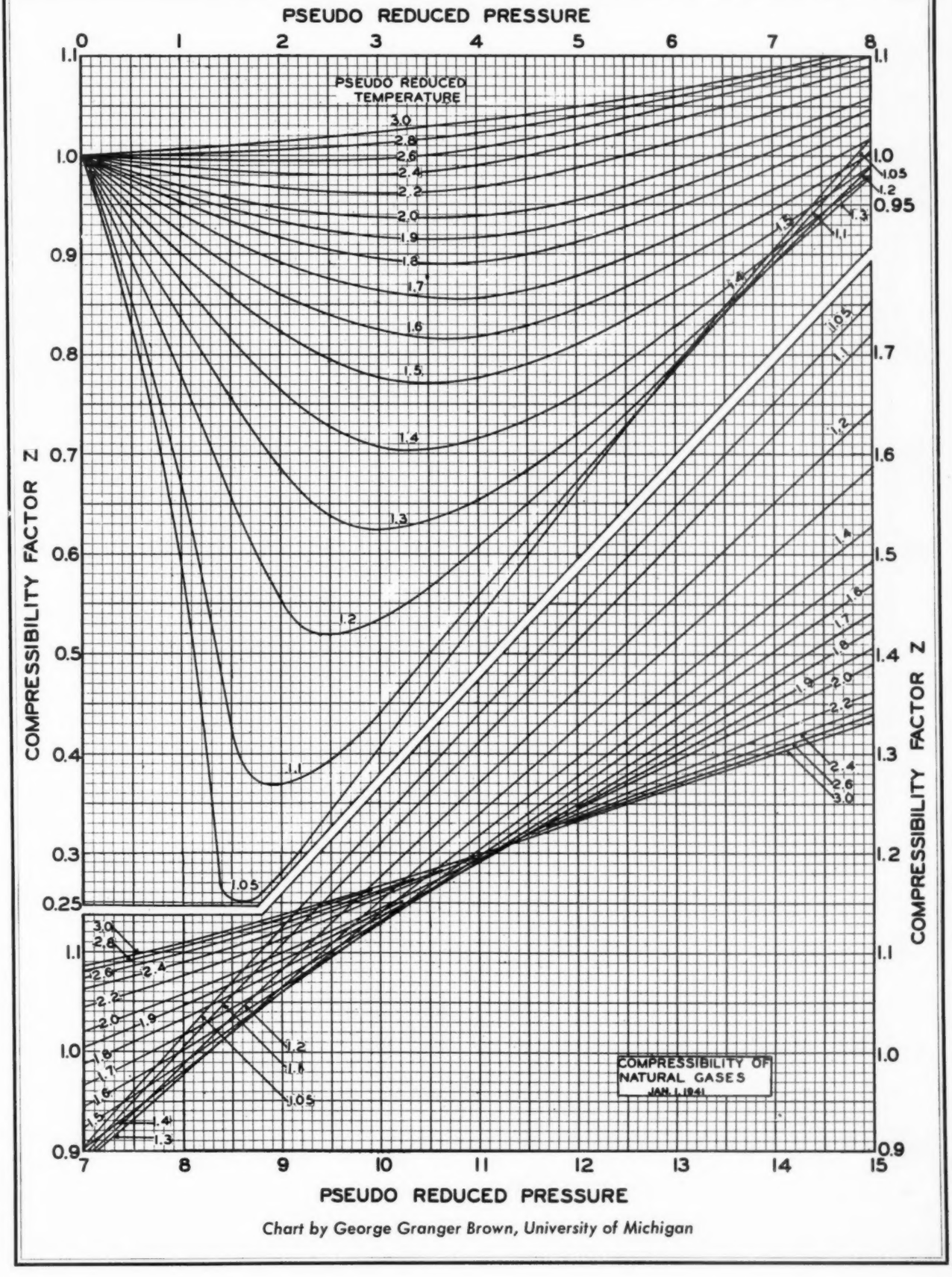


Chart by George Granger Brown, University of Michigan

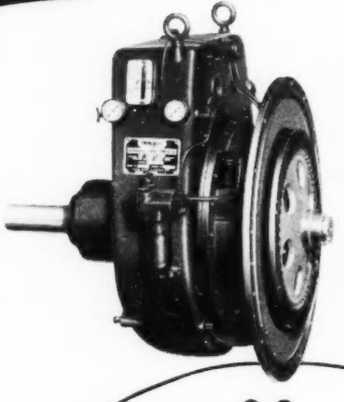
LET'S GIVE 'EM *Both* BARRELS

Let's keep our eyes on the target—give 'em BOTH barrels.

1. Full time on the job—no lay-offs for personal whims or preventable sickness.

2. Full 10% or more invested in War Bonds every pay day.

The boys in uniform will do the rest to make Victory certain and quick.



Assure longer wear-life . . . save repairs . . . prevent failure of your Twin Disc Torque Converter by following instructions in the booklet, "General Instructions for the Care and Operation of Twin Disc Hydraulic Torque Converters," furnished free to owners and operators.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U. S. PAT. OFF.

TWIN DISC CLUTCH COMPANY • RACINE, WISCONSIN

24-HOUR CAPACITY* OF 4-IN. BY 2¾-IN. ORIFICE PLATE—FLANGE CONNECTION

Pressure, lb. per sq. in. ga.	Differential, in. of water										
	5	10	20	30	40	50	60	70	80	90	100
10	618	869	1231	1509	1737	1943	2133	2300	2461	2611	2751
20	802	1036	1459	1787	2066	2311	2528	2734	2923	3096	3268
30	830	1175	1659	2032	2344	2623	2873	3107	3319	3519	3708
40	919	1297	1837	2249	2600	2906	3179	3435	3675	3898	4109
50	997	1414	1999	2450	2829	3163	3463	3736	3993	4248	4471
60	1075	1520	2149	2628	3040	3396	3719	4020	4298	4555	4805
70	1141	1620	2288	2801	3235	3619	3964	4282	4577	4855	5117
80	1208	1709	2420	2962	3424	3825	4193	4527	4839	5134	5412
90	1275	1798	2545	3118	3597	4026	4410	4761	5089	5395	5690
100	1331	1882	2662	3263	3770	4209	4616	4983	5329	5652	5958
110	1386	1966	2778	3402	3925	4393	4811	5195	5557	5891	6208
120	1442	2043	2890	3536	4081	4566	5000	5401	5774	6125	6453
130	1498	2116	2990	3664	4232	4733	5184	5596	5986	6348	6693
140	1553	2188	3096	3792	4376	4894	5362	5791	6186	6565	6921
150	1598	2261	3190	3909	4516	5050	5529	5974	6386	6771	7138
160	1643	2327	3291	4026	4649	5201	5696	6153	6576	6977	7355
170	1687	2389	3380	4143	4783	5345	5858	6325	6765	7172	7561
180	1737	2455	3474	4254	4911	5490	6013	6498	6943	7366	7762
190	1782	2517	3558	4360	5033	5629	6164	6659	7121	7550	7962
200	1821	2578	3647	4466	5156	5763	6314	6821	7294	7734	8151
210	1865	2639	3731	4571	5273	5897	6459	6977	7561	7912	8341
220	1904	2695	3814	4672	5390	6030	6604	7133	7622	8085	8525
230	1949	2751	3892	4766	5507	6153	6743	7283	7784	8257	8703
240	1988	2806	3970	4866	5618	6231	6876	7428	7946	8424	8881
250	2027	2862	4048	4961	5724	6403	7016	7572	8096	8591	9054
260	2060	2918	4126	5050	5835	6520	7144	7717	8252	8747	9226
270	2099	2968	4198	5145	5941	6637	7272	7856	8397	8909	9388
280	2138	3023	4271	5234	6041	6754	7400	7996	8547	9065	9555
290	2171	3074	4343	5323	6142	6871	7522	8129	8692	9215	9716
300	2210	3124	4415	5407	6242	6982	7645	8263	8831	9365	9872
310	2244	3174	4488	5496	6342	7094	7767	8391	8970	9516	10028
320	2277	3218	4555	5579	6442	7199	7884	8519	9109	9660	10184
330	2311	3268	4621	5657	6537	7305	8001	8647	9242	9805	10334
340	2344	3313	4688	5741	6631	7411	8118	8770	9377	9944	10485
350	2378	3363	4755	5824	6721	7517	8235	8892	9505	10083	10629
360	2411	3408	4816	5902	6815	7617	8346	9015	9638	10223	10774
370	2439	3452	4883	5980	6904	7717	8458	9132	9766	10356	10919
380	2472	3497	4944	6058	6993	7817	8564	9254	9889	10490	11058
390	2506	3541	5006	6130	7082	7918	8675	9365	10017	10624	11197
400	2533	3586	5067	6208	7166	8012	8781	9482	10139	10752	11336
410	2567	3630	5128	6281	7255	8113	8887	9599	10262	10880	11470
420	2595	3669	5183	6359	7339	8207	8987	9711	10379	11008	11604
430	2623	3714	5251	6431	7422	8302	9093	9822	10501	11136	11737
440	2656	3753	5306	6503	7506	8391	9193	9928	10618	11258	11871
450	2684	3797	5368	6570	7589	8486	9293	10039	10730	11381	11999
460	2712	3836	5423	6643	7673	8575	9393	10144	10846	11503	12127
470	2739	3875	5479	6709	7751	8664	9493	10251	10963	11626	12255
480	2767	3914	5535	6782	7829	8753	9588	10356	11058	11743	12383
490	2795	3953	5590	6849	7907	8842	9688	10462	11186	11865	12506
500	2823	3992	5646	6915	7985	8931	9783	10568	11297	11982	12628

4-in. x 2¾-in. orifice plate size, flange connection.
*Million cu. ft. based on (4 oz.) 14.4 lb. per sq. in., 0.60 gravity, and 60°F. temperature.

1 hour coefficient = 2320.0
24 hour coefficient = 55680.0

Your scrap coming in every day helps steel men keep their war-steel furnaces at peak production

COPYRIGHT 1943 — JONES & LAUGHLIN STEEL CORPORATION

FROM AN ORIGINAL DRAWING BY ORISON MACPHERSON

675,000 STEEL INDUSTRY WORKERS SALUTE 130 MILLION AMERICANS

The splendid results achieved by the public in the scrap-metal drives are being manifested 24 hours a day, seven days a week, in the production of more and more fighting steel by America's army of steel workers.

However, need goes on for more scrap to keep war-steel furnaces up to full production. The metal in community salvage piles is being steadily hauled away and prepared by dealers for use in the steel works. Your local scrap heaps are reservoirs that must be kept filled and scrap collections should go on, month after month. The neighborhood scrap piles should not be regarded as unsightly, but as something in which you may take pride as symbols of America's fighting spirit.

JONES & LAUGHLIN STEEL CORPORATION

PITTSBURGH, PENNSYLVANIA

CONTROLLED QUALITY STEEL FOR WAR

J&L STEEL

CHARTS FOR CALCULATING COOLING TOWER REQUIREMENTS

The three charts and examples included in this table are for the purpose of showing how the approximate size of a cooling tower may be designed.

Conditions: To cool 1500 gal. per min. from 90° to 75° F. with a 3 mile per hour wind and a 70° wet bulb.

Problem 1. Under these conditions how many 6 ft. sections of a 35 ft. high × 12 ft. wide, 12 deck tower are required to accomplish the cooling.

Solution:

T_1 = (inlet temperature) = 90° F.

T_2 = (final temperature) = 75° F.

T_w = (approach to wet bulb) = 75 — 70 = 5°.

C = concentration per sq. ft. of horizontal deck area obtained from Fig. 1.

A = area of one standard tower section, 12 ft. wide and 6 ft. long = 72 sq. ft.

N = number of 12 ft. wide, 6 ft. long tower sections.

To determine the number of sections under the above conditions, the following equation is used:

$$\frac{\text{Gal. per min.}}{C \times A} = N$$

From Fig. 1, C for 35 ft. high tower, for a T_w of 50° and a $T_1 - T_2$ of 15° = 1.17. Substituting in the above equation:

$$\frac{1500}{1.17 \times 72} = 17.8$$

Therefore, under the conditions an 18 section tower 35 ft. high is required.

Problem 2. If the wet bulb is other than 70° upon which Problem 1 is based a wet bulb correction factor must be used. This factor is C_w, obtained from the wet bulb curve Fig. 2. The problem then becomes one of figuring the number of sections required with the same tower height.

Conditions: Wet bulb 65°, 5° approach, 15° temperature drop or $T_1 - T_2$.

Solution: To determine the number of sections under these conditions, the following equation is used:

$$\frac{\text{Gal. per min.}}{C \times C_w \times A} = N$$

C from Fig. 1 for a 35 ft. high tower, a T_w of 5°, and a $T_1 - T_2$ of 15° = 1.17.

C_w (correction factor for wet bulb) is obtained from Fig. 2 and = 0.85. Then substituting in the above equation:

$$\frac{1500}{1.17 \times 0.86 \times 72} = 20.8$$

Therefore under these conditions a 21 section tower 35 ft. high is required.

Problem 3. Assuming that a 35 ft. high tower does not meet cooling requirements due to plant conditions, then a tower of greater or lesser height must be figured. It is then necessary to apply a height correction factor. This factor, C_h is obtained from the height curve Fig. 3. If a tower 51 ft. high, instead of 35 ft. high, is necessary for conditions stated, the following equation is used:

$$\frac{\text{Gal. per min.}}{C \times C_h \times A} = N$$

C_h, correction factor for height, is obtained from Fig. 3 and = 1.63.

Then substituting in the above equation:

$$\frac{1500}{1.17 \times 1.63 \times 72} = 10.9$$

Therefore, under these conditions an 11 section tower 51 ft. high would be required.

In Problem 3, if the wet bulb is other than 70°, C_w, the wet bulb correction factor becomes a part of the equation:

$$\frac{\text{Gal. per min.}}{C \times C_w \times C_h \times A} = N$$

Note: Engineering data and the above examples are approximate only and the sizes of the towers determined should not be regarded as recommendations.

Charts and data supplied by The Fluor Corporation, Ltd.

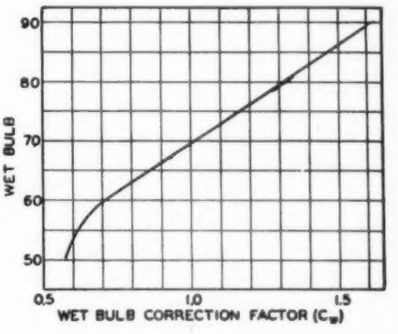


Fig. 2. Wet bulb performance factor

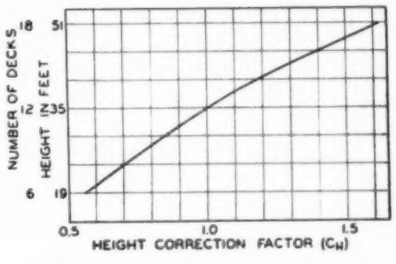
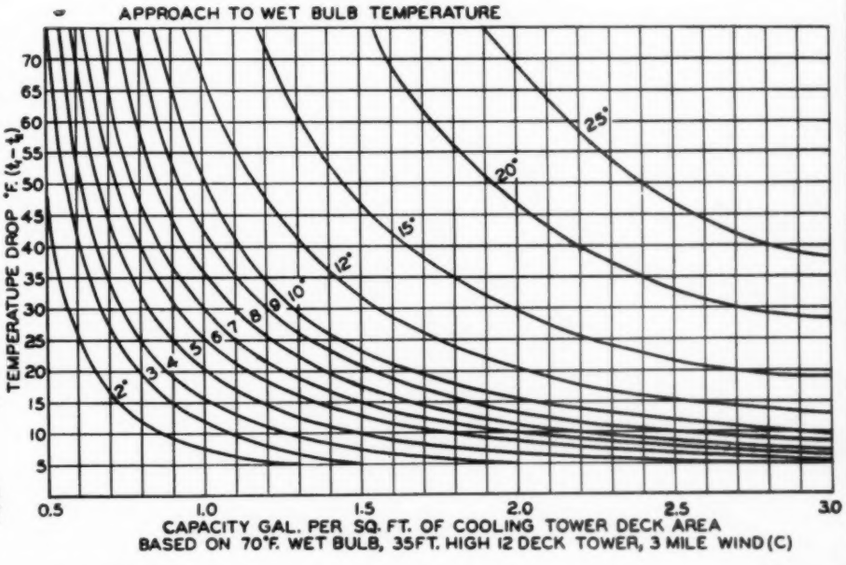
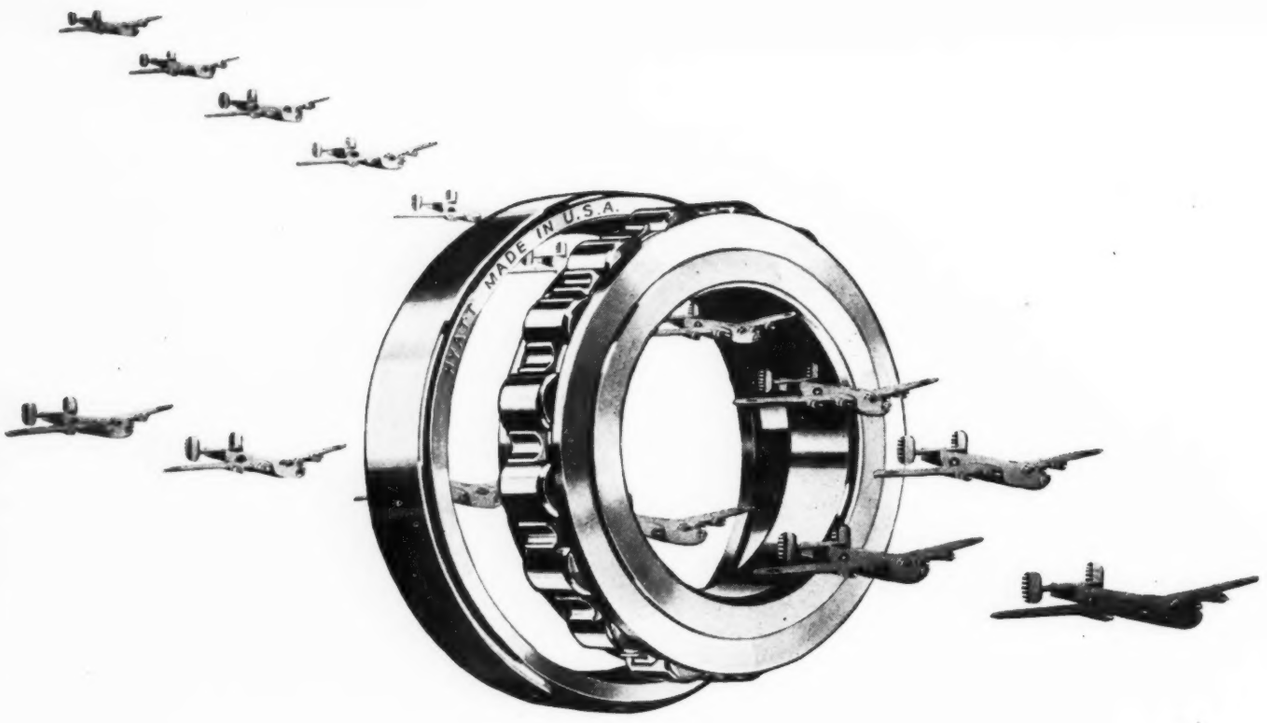


Fig. 3. Tower height performance factor

Fig. 1. Capacity curves





High Precision

Aviation is but one of the many important applications where Hyatt Roller Bearings are battling the Axis.

Their proved performance under fire in aircraft as well as in tanks, guns, ships and trucks . . . their wartime round-the-clock operation in factories, on farms and railways . . . all reflect the many important advantages of their advanced design and high precision manufacture.

This is the kind of bearing precision and performance which builders and users of oil well equipment have come to know well over the many years we've served, and will continue to serve, in the brighter years ahead.

Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

P 436.2
P 094.99

Effecting Greater Recovery Of Well Casing

PETROLEUM ENGINEER Exclusive Feature

☆ The making of definite plans when well is drilled, aids successful pulling of casing later

by F. R. Cozzens
District Field Manager, Equity Oil and Gas Company

THE greatest, and by far the most common, waste of metal that occurs in the production branch of the oil industry is the loss of casing, countless tons of which lie buried in practically every major oil district in the United States. In a small, southern Ohio district, where 130 wells were salvaged and abandoned a few years ago, the pulling crew boasted of their record of having lost on an average of only four sections of casing for every ten wells. Considering the fact that the salvaged casing (6⅞ in.) weighed 300 lb. per 20-ft. section, the minimum waste of the 52 lost sections meant 15,600 lb. of metal, which from this one district alone would have been a worthwhile contribution to the local scrap drive.

New Practices

In pre-war days, when the loss of casing affected only the owner, a limited amount of time was taken in starting a stubborn string from a well. When casing failed to "come free" readily by block-and-line technique, a ripper or explosives were brought into action, and the sections, beginning at the bottom, were knocked-off one by one until the rest of the string was released. This and kindred wasteful practices are no longer tolerated in many parts of the Eastern stripper oilfields. The great majority of operators are now aware of the fact that the saving of metals is a duty, vital not only to themselves and the industry, but likewise to their country. In the drilling of new wells, formations are studied and plans made for the removal of casing before the pipe goes into the ground. Non-essential cementing is avoided. Where cement was formerly used merely as a means of shutting off water or cavings, packers made of burlap and twine, asbestos fiber or rock-wool, and anchored with clay or muck, will serve the purpose exceptionally well with no bad after effects. In many cases where a cement job is necessary, these temporary packers can often be run and backed-up later with cement if the well becomes a producer. The need of building an artificial shoulder with cement on top of a pay sand is being avoided in many areas by reducing the diameter of the hole at that point, thus leaving a natural shoulder upon which the casing rests.

Casing Lime Zones

In the actual running of casing, it is generally found best to leave no collar on the lower end of the bottom section. In certain areas, especially where conditions are similar to those in northwestern Ohio where 1000 ft. or more of lime must be drilled, it is common practice not to set the thread on the two bottom sections up as snug as the others. Space between the bottom walls of the hole and the lower sections of pipe forms a reservoir for lime deposits. When the casing must be pulled, only the extreme low sections are bound, and being less securely threaded, break loose at that point, allowing the remainder of the string to come free. Threading of all other sections, however, should be complete, and collars set tight to the pipe. Entirely too many strings break in the wrong place because of cross-threading or otherwise damaged threads. A very important part of casing equipment are wire brushes for cleaning threads, and a bucket of oil for lubricating them before sections are joined up. After a string has been run and properly seated, a burlap wrapper should be placed around the top section at or near the top of the drive-pipe, to shut off surface water and sand pumpings.

When a newly-drilled well is found to be dry, the casing-pulling job is not delayed for days or weeks as it was formerly. If the pulling crew is not available immediately, arrangements are made for lifting the string, a few feet at least, off bottom. If the pulling job threatens to be stubborn the casing is generally filled to the top with water. This practice keeps deposits from hardening in the pipe, and provides weight for relieving suction at the bottom of the well.

Releasing Stuck Pipe

The most difficult pulling jobs, and the greatest loss of pipe, occur in districts where casing has remained in the ground for a number of years. When such wells are within a district where secondary recovery by air-drive has been used, time, money, and materials can be saved by leaving the compressors and air-lines intact until the casing has been salvaged. There are various ways of using air-pressure to aid in pulling casing, one of the most effective methods being to build up air pressure within a well to counteract the grip of residue on the bottom sections. After considerable tension with blocks and line fails to start the string, a special head is screwed over the casing top, connections are made with the compressor, and air is pumped into the casing. Pulling machinery is again started and tension gradually increased. As lifting power increases, air pressure accumulates, pushing sludge and residue downward until a release is made under and around the bottom section of casing. Bottom grip is thus broken and free air, forced upward and around the outside of the casing, greatly reduces binding along the walls. After the string has started, air is released through a valve in the casinghead. Binding, or friction along the walls can, if from lime deposits, be relieved in some cases by introducing into the well, around the outside of the casing, small quantities of hydrochloric acid (muriatic acid), that has been treated with chemicals to prevent corrosion of metal.

The primary requirement of all casing pulling is sufficient power for the job. By combining this power with means to make it most effective, the operator saves labor as well as materials, and hastens the day when oil can again be produced on a stabilized basis.

——— ☆ ☆ ☆ ———

MACHINERY and EQUIPMENT

Arc-Welding Control

A Unique type of arc-welding control, which enables the welder to speed-up his work and do a more accurate job, has been announced by The Lincoln Electric Company, Cleveland, Ohio.

This control, called the "Lincontrol," which is almost as light as a shoe, is strapped onto the welder's foot and enables him to move about with it freely. It is specially intended for aircraft welding, but is applicable for welding of light-gauge sheet metal of all kinds. Because it is so easily used, it will be a boon to women welders, who are taking up this type of work in aircraft plants in increasing numbers, the manufacturer asserts.

With the control strapped to his foot (see illustration), the welding operator merely presses down on the pedal, which moves the pin to operate a current control. As he exerts pressure he increases the current.

This permits accurate control over the welding arc, and achieves in one unit the same results as both the so-called "hot-start" and "crater eliminator." Because he has complete control, he can adjust the arc at any time without changing his position. Yet while welding in and around a fuselage assembly on "pick-up" work, he can move around at will without the hindrance of constantly keeping his foot in one place as is necessary with conventional foot controls.

Thus, the control eliminates the necessity of making adjustments on the welding machine, due to such things as minor changes in thickness, and changes in fit-up, and enables the operator to weld in any position that he finds convenient or comfortable. The complete control of the arc gives an improvement in the quality of the weld, reducing the danger of a weld burning through or getting poor fusion or penetration.

The control is sold for $25 with 20 ft. of cable that can be plugged into a socket on the welding machine. It is designed for the Lincoln "Shield-Arc Junior" welders. Lincoln "Junior" welders now in the field can be adapted for the control by any shop electrician by obtaining a new voltage rheostat for the welder.

Sold separately from the welding machine, the controls can be delivered in a short time, the manufacturer states.

"Fuse-Bond" Process For Metallizing Electrically

METALLIZING ENGINEERING COMPANY, INC., announces a new Fuse-Bond Process, and equipment for its application, whereby machine components and similar metal parts now may be prepared for metallizing electrically. Principal advantage of the process is that it affords an adequate bond on the hardest surfaces, heretofore impossible or impractical to prepare by blasting or rough threading, the company states. It also simplifies preparation of narrow edges, flat areas, and cylindrical parts having keyways, and other interruptions in their surfaces.

Application of the process is with the Metco Fuse-Bond Unit. Operating on any 110- or 220-volt, single-phase power line, this equipment fuses a rough deposit of electrode metal into the surface to be metallized. Electrodes are applied to the work with a special holder that uses up to six electrodes at a time, depending on the size and nature of the part to be prepared. Small parts may be prepared with this equipment as easily as large shafts, as there is no excessive heating of the base metal, or disturbing of its physical characteristics.

The Fuse-Bond Unit is extremely compact, and is contained in a cabinet measuring only 24 in. high. Weight complete is 170 lb. All cables and attachments fit into a bin in the top of the cabinet. Mounted on casters, it can be wheeled right to the job with ease. A complete Instructional Manual provides all operating data. Unskilled labor can operate efficiently within an hour or so. Further information on the process and its equipment is contained in Bulletin 44, obtainable from Metallizing Engineering Company, Inc., Long Island, New York.

SAFE WAYS IN WAR PRODUCTION

NEW WORKER—Every new employee in a Bethlehem Plant wears this button. It helps to fix his attention on safety. It signals to more experienced employees that he is new to the plant, and they keep an eye on him, and do not hesitate to offer friendly guidance in case he forgets instructions and unknowingly breaks any safety regulation.

Industrial accidents, bad enough because of the human distress they cause, are also a grievous drag on production. Every day that injury lays up a worker means lowered output of the materials our armed forces are asking for.

Safety engineers know they must be more than ever on guard as pressure for production intensifies and men work against time. When war came, Bethlehem Steel Company expanded its accident-prevention program to meet the new conditions. Special efforts were addressed to the new employee to make him safety-conscious from the moment he walked into the plant. And by posters, group meetings and individual instruction, the safe way of doing his job was ground into the subconscious of new Bethlehem employee and veteran alike.

Significant are the results of a current study, showing that of all disabling accidents to Bethlehem employees less than one-third occur in the course of their work. Even with employment rolls upped by the tens of thousands and plant operations at top speed to meet the demands of the war program, the Bethlehem employee is safest, best protected against injury, during the hours he spends on the job.

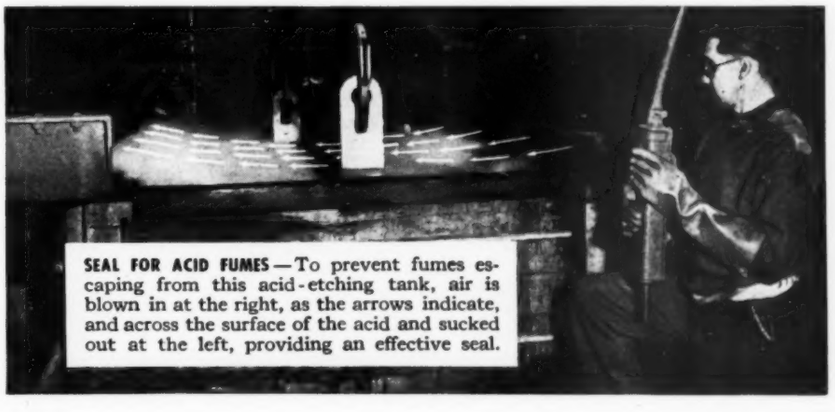
AUTOMATIC HAND GUARD—This man is operating a trimming press. If he should absent-mindedly let his hands move too near the danger zone, the two cables will automatically whisk them back to safety, before the ram of the press descends.

100% HEAT-INSULATED—Asbestos-covered hood, chrome-leather full-length apron, chrome-leather gloves, chrome-leather full-length sleeves and asbestos guard on torch handle give this worker complete protection against heat and flying sparks.

EYES DOUBLY GUARDED—Even though this grinder is equipped with a heavy glass shield, the eyes of the man who is operating it are given further protection against sparks or flying bits of abrasive by the cup goggles that he is wearing.

BETHLEHEM STEEL

Bethlehem Steel Company is actively supporting the National Safety Council in its campaign against accidents in war production, through the War Production Fund to Conserve Manpower.



SEAL FOR ACID FUMES—To prevent fumes escaping from this acid-etching tank, air is blown in at the right, as the arrows indicate, and across the surface of the acid and sucked out at the left, providing an effective seal.

Pressure and Detonation Pickups

ELECTRO pressure and detonation pickups are used with Diesel and gas engines, also pumps, compressors, and similar mechanisms to record instantaneous pressures and other phenomena occurring within the firing or compression chambers. It consists of a magnetic type pickup, having a diaphragm, which is exposed to the explosion or pressure forces within the cylinder; the vibration of the diaphragm produces magnetic flux variations in a coil assembly that provides an output voltage having identical characteristics to the varying pressures developed in the cylinder.

Two types are now available, namely, Models No. 3000 and No. 3000A. The Model No. 3000 fits into a hole in the cylinder, which is tapped to receive a $\frac{7}{8}$-in. 18 thread. The No. 3000A fits into the standard aircraft engine 18MM spark plug hole.

Output voltages as high as 40 mv. are obtainable from these pickups when used with the standard C.F.R. gasoline testing engine using 70-octane rating gasoline, the voltage being total of detonation and regular explosion. Should detonation or any cyclic engine pressure voltage be required, the Electro Filter Model No. 2300 can be used to select these voltages over a range from 2000 to 8000 cycles.

These pickups are designed for operation at excessive temperatures met with in gas engines because of the high temperature insulation over the fine windings of this pickup, also proper ventilation. Special construction of the pickup eliminates binding post connections. It is only necessary to screw on the socket attached to a shielded 7-ft. cable to the end of the pickup and then a completely shielded connection is automatically made to the pickup terminals. The complete electrical shielding of the pickup and cable eliminates ignition and other undesired electrical interference.

Two types of diaphragms are supplied with each pickup, one for ordinary pressures met with in gas engines and compressors and the other for high compression aviation engines.

Reset Timers

THE new Cramer RS4 and RS5 synchronous motor-driven timers are of the reset type and are now available for time ranges up to 5 hours and longer if desired.

These new timers have a wide application for accurately timing any electrical circuits.

These timers repeat their time cycle upon manual operation of a built-in start button and they indicate at a glance, by means of a progress indicator that moves toward the zero mark of the scale when in operation, the expired and unexpired time cycle as well as the setting time.

The RS4 timer has a double throw switch and opens or closes the circuit, depending upon the choice of circuit, and starts by pressing and then releasing the start button, which also resets the timer. The RS5 is different in that it is mechanically held in a neutral position when the button is depressed, and it starts the timing cycle by pulling the start button outwardly.

These timers operate a single-pole, double-throw switch with a capacity of 10 amp. at 115 volts or 5 amp. at 220 volts a-c. non-inductive load, and will control a $\frac{1}{3}$-hp. motor load, a heater load of up to 1200 watts, a lamp load of up to 250 watts, or a relay load that does not exceed 15 amp. inrush at 115 volts a.c.

Both models are encased in an attractive black bakelite case designed for flush panel mounting. They can also be supplied in dustproof or moistureproof surface mounting steel housings, as well as in explosionproof cases, arranged for conduit connections, and also with built-in visual or audible signals.

The equipment is manufactured by the R. W. Cramer Company, Inc., Centerbrook, Connecticut.

WHAT'S A BRAND WORTH?

First of all a brand is valuable because it permits immediate identification. On each JoneSuckeRod or coupling there is a complete "case history," plainly marked. For instance: J for Jones, 7 for Type 7, then the API marking, size and heat number. These markings are extremely valuable to operators who keep rod records. Also to the Jones experts who "check back" on rod service, and thus improve rod quality.

Yet, identification is only part of the story. For 51 years the Jones brand has meant sucker rod leadership. Leadership through developing the first all-metal sucker rod, the first streamlined forging, fully normalizing, etc. By pioneering Well Studies and Laboratory Research through advanced Engineering and Metallurgy.

Today, Jones is leading in a campaign to aid the war effort by helping oil men everywhere to increase the efficiency and service life of rods now in use.

What's a brand worth? Whatever its owner makes it worth to you!

The S. M. JONES Co.
JoneSuckeRods
General Office and Factory, Toledo, Ohio — Sales Office, McBirney Bldg., Tulsa, Okla.

Steelgrip Gear and Wheel Puller

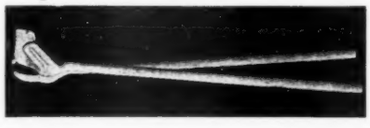
ARMSTRONG-BRAY AND COMPANY, Chicago, Illinois, announce the addition to their line of Steelgrip Rigid-arm Gear and Wheel Pullers.

The new pullers add to a line that will take care of a wide range of jobs, covering factory work, tank, tractor, truck and farm machinery maintenance, etc., it is asserted.

The new Steelgrip Rigid-arm Gear and Wheel Pullers are of the same rugged construction as the rest of the line: the forged steel arms, forcing screw, etc., are heat-treated for great strength. They are made in three sizes. Circulars will be supplied further describing this tool.

IPCO Safety Drum Opener

THE IPCO Safety Drum Opener is designed to save time and reduce the hazards in opening light and medium weight drums. It cuts smoothly, quickly and evenly, and folds in the cut



edge close to the side, the manufacturer states.

The operation of the tool is simple, being made by a series of downward strokes similar to the can opener principle. When the head is entirely cut through it is removed by grasping with beaks of the tool.

The tool is made of steel drop forgings, hardened and tempered. It is a powerful tool and will give satisfaction under severe service, the makers state.

Further details may be had upon writing to Industrial Products Company, 2820 North Fourth Street, Philadelphia, Pennsylvania.

Gypsum Products For Construction

A GROUP of new gypsum products developed to meet the immediate demands of wartime construction has been put on the market by The Celotex Corporation, Chicago, Illinois. The new products replace more critical materials, such as steel and lumber, in both temporary and permanent structures, according to Henry W. Collins, vice-president. WPB is advocating the use of such gypsum products in place of less available materials.

The products include a new gypsum exterior siding covered either with smooth or mineral surfaced roofing; laminated gypsum wallboard panels suitable for demountable or permanent single wall interior partitions; laminated gypsum roof deck slabs, and poured gypsum roof decks for use with wood-frame industrial construction.

The new White Rock Gypsum exterior wallboards supply both structural and weather protection needs for many "Theatre of Operations" buildings such as barracks, warehouses, recreation centers, and repair shops. The products also are applicable to war workers' homes, dormitories, and industrial buildings.

White Rock Extra Thick Gypsum wallboard panels are made in 1-in., 1½-in., and 2-in. thicknesses by laminating two, three, or four layers of gypsum wallboard. This provides a core of fireproof gypsum that will not warp, twist, expand, or contract.

The Celotex gypsum roof slab is an improved rigid type of roof deck plank. It may be used to replace wood plank or other types of unit roof deck construction. The slabs are made by laminating together two, three, or four thicknesses of White Rock wallboard to form an integral unit.

Celotex poured gypsum roof deck is designed for use on any type of industrial building, warehouse, garage, or hangar.

If you have troubles enough without worrying about pumping power, the Case Oilfield Engines can contribute to your peace of mind. They are built to run non-stop for surprisingly long periods, to require a minimum of attendant labor, and to go on year after year with very moderate expense for mechanical renewals and adjustments.

Consistently low oil consumption, long-lived lubrication of the few external parts, exceptional thoroughness in exclusion of dust and dirt, conservative speeds and bearing loads are among the reasons for the endurance of Case Oilfield Engines. Cutouts acting on high temperature and low oil pressure are available to guard against mishap or neglect, permitting safe operation unattended.

These engines, in 40 and 60 horsepower sizes, are available for operations deemed vital to the war effort. For full information get in touch with your Case distributor or write us. J. I. Case Co., Racine, Wis.

SOUTHWEST EQUIPMENT COMPANY
Dallas and Kilgore, Texas
LELAND EQUIPMENT COMPANY
Tulsa, Oklahoma
ALLIED SUPPLY COMPANY
Los Angeles, Calif.

CASE

Since 1842 IN PEACE AND WAR

Union Wire Rope Navy "E" Award Renewed

The Union Wire Rope Corporation, Kansas City, Missouri, has been notified by the Navy Department of the renewal of its Navy "E" award for excellence in war production. In a letter addressed to M. G. Ensinger, president of the company, Rear Admiral George H. Rock, chairman, Navy Board for Production Awards, Washington, D. C., said:

"I am glad to advise you that after careful consideration at its last meeting, the Navy Board for Production Awards granted a renewal of the Navy "E" Award to the Union Wire Rope Corporation for an additional period of six months dating from November 15, 1942.

"This renewal grants you the right to add a white star to your pennant. I am therefore forwarding to you through the Commandant of the Ninth Naval District a new pennant with one star affixed, which you should receive in the near future.

"The question of a ceremony in connection with hoisting the new pennant is left entirely to your desires in the matter. Should you elect to have a ceremony, the local Navy Public Relations Officer will be at your service to assist you in any way possible.

"I congratulate each and every one of the employees of the Union Wire Rope Corporation upon their continued splendid achievement in outstanding production. This award is difficult to win in the first instance and the requirements for renewal are equally exacting. By winning this additional honor you all have demonstrated a solid determination to supply our fighting forces with the materials they must have to bring this war to a successful conclusion."

Oil City Tank and Boiler Changes Name

The Oil City Tank and Boiler Company, Oil City, Pennsylvania, has changed its name to Electroweld Steel Corporation. There have been no changes in management or directors.

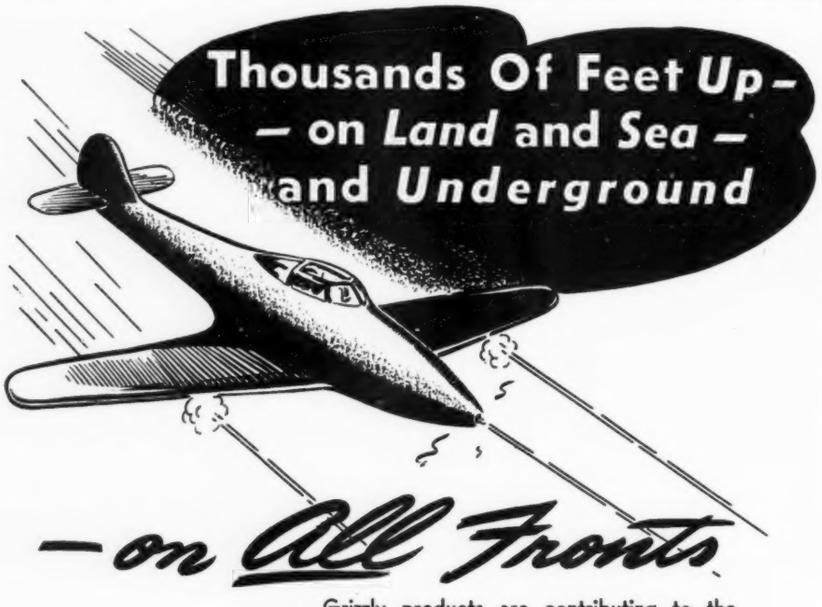
The product of this widely known boiler company has been discontinued permanently and the entire manufacturing facilities are now devoted to the production of Electroweld Tubing. One of the world's most modern electric resistance weld tube mills has been installed. It is now producing invasion tubing for the armed forces at a rate of many miles a day. More than that, a new mill, now being built, will increase greatly Electroweld production.

This company has announced the change of name and its new product in nine leading trade publications. It immediately took an aggressive sales and manufacturing policy to assure successful operations during the peacetime era.

New Officers Elected by Los Angeles Nomads

Officers for the year 1943 were elected at the annual meeting of the Los Angeles Chapter of Nomads held in Los Angeles, Wednesday evening, January 13, 1943. Ballots were opened at a business session preceding the regular dinner by past presidents of the Chapter, Elmer Decker and Ted Sutter. The result of the voting was: Henry Pullman, president; Roland Smith, vice-president; Wallace A. Sawdon, secretary; Tom Martin, assistant secretary; Elmer Smith, treasurer; Roger Henquet, assistant treasurer; J. V. Robinson, sergeant-at-arms, and George Trembley, deputy sergeant-at-arms.

The National Regents elected to represent the Chapter on the Board of Regents of the Nomads were W. F. (Bill) Bettis and W. R. (Frosty) Martin. Plans for the fourth annual inaugural ball to be held in February were then discussed and H. E. Cassidy, Lew Bronzan, and Wallace Sawdon were appoint-



Grizzly products are contributing to the fighting efficiency of war equipment on many battle fronts . . . in the air, and on land and sea.

Here on the home front they are serving in manufacturing plants, on our streets and highways, in lumber camps, and miles underground in oil wells, to maintain and improve operating safety, efficiency and economy.

When all-out aircraft production required rubber products that would enable new and faster methods, for example, Grizzly engineers, with a background of more than 25 years of highly specialized experience, were ready with products of proven merit to meet these demands. Various fighting aircraft and mechanized units are manufactured and equipped with Grizzly products.

Grizzly is doing the biggest job of its entire career, and is proud of its contribution to the war effort. War demands come first, of course, but Grizzly is taxing its facilities to the limit in order to meet the requirements of the petroleum and other industries on the home front.

Consult us regarding any rubber requirement or development. Grizzly engineers are solving a wide range of particularly difficult rubber problems for manufacturers in many different industries.

GRIZZLY MANUFACTURING CO.
(Formerly E. M. Smith Co.)
Plants: Los Angeles, California. Paulding, Ohio.
Complete Stocks Maintained in our Warehouses At:
407 Velasco Street, Houston, Texas. 1008 S. E. 29th St., Oklahoma City, Okla.
1621 East Yellowstone, Casper, Wyo.
Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York, N. Y.
Distributed by Leading Supply Companies.

ed to aid the Entertainment Committee consisting of Roland Smith, chairman, and J. V. Robinson in making final arrangements for this affair.

The speaker of the evening was Boyd Comstock, who was introduced by Lew Bronzan, master of ceremonies for the meeting. Comstock was the Olympic Coach and Director of Athletics in Italy for a number of years before war was declared between Italy and the United States. When war broke out he had the job of getting back home but after being exchanged finally reached this country on July 4, 1942. His remarks were devoted to the Italian situation and to the hardships being endured in Italy, particularly under the present German control.

Many guests were present at the meeting, among whom were the following men from foreign oil fields: S. E. Charlebois of Shell de Colombia; Claude E. Goss of Caribbean Petroleum Company; C. H. Strickland of Iraq Petroleum Company; R. H. Conners of Iraq Petroleum Company; A. F. Driskill of Iraq Petroleum Company; W. T. Masters of Tropical Oil Company; D. D. Hilyard of Conselho Nacional du Petroleo; George Witzlebew of U.B.O.T.; E. E. Detter of U.B.O.T.; J. C. Bentz van den Berg of B.P.M., and W. F. Parraga of C.A.S.O.C.

Bucyrus-Erie Awarded Second Army-Navy "E"

The Army-Navy "E" award was presented to the Erie Works of Bucyrus-Erie Company on January 16. Previously, the company's South Milwaukee plant had received the same distinguished honor for production achievement.

Col. John S. Seybold, chief of the Army Procurement Branch, Supply Division, Office of the Chief of Engineers, in presenting the "E" banner emphasized the importance of construction equipment in the conduct of this highly mechanized war. W. L. Little, manager of the Erie Works, accepted the award on behalf of the company.

Army-Navy "E" to Westinghouse

Brigadier General A. G. Gillespie, commanding officer of Watervleit Arsenal, Watervleit, New York, recently made the award of the Army-Navy "E" pennant for excellence in war production to the East Springfield, Massachusetts, plant of the Westinghouse Electric and Manufacturing Company. This is the eighth such award to be won by the Westinghouse company, according to W. O. Lippman, works manager.

Formerly devoted to the production of refrigerators, vacuum cleaners and other electrical appliances, the East Springfield plant now is engaged in manufacture of equipment essential to the war.

Lowell Thomas, radio commentator, acted as master of ceremonies, and John Charles Thomas, celebrated baritone, led in singing the national anthem. The program was broadcast over radio stations WBZ-WBZA.

Individual Army-Navy "E" emblems were awarded the Westinghouse workers by Capt. Gordon C. Hall, accounting officer of the Boston Navy Yard, and were accepted for the employees by Leo Benoit, president of Local 202, United Electrical, Radio and Machine Workers of America.

Lieut. Col. J. M. Colby, chief of the development section of the United States Army Ordnance Department's tank-automotive center in Detroit, reported to Westinghouse employees on the performance of equipment they make for tanks. Colonel Colby recently returned from Egypt, where he observed desert fighting for 11 months. Gov. Leverett Saltonstall of Massachusetts and Mayor Roger L. Putnam also spoke at the ceremony.

GREATNESS IS MEASURED BY SERVICE

HILL-HUBBELL
Steel Pipe Protection
EXCELS IN SERVICE

In American hearts Washington and Lincoln are great because their ideals, their labours and their services to the country have endured.

Industry, too, is serving through progressive developments in war and in peace.

Sound engineering principles, good materials and honest craftsmanship shall continue in HILL-HUBBELL Steel Pipe Protection. This is our service—the only way we know to build enduring acceptance of our product.

A request on your letterhead will bring a copy of The Book of Pipe Protection, which describes our process in detail.

HILL-HUBBELL Mill applied coating and wrapping is available at these leading mills.

- Jones and Laughlin Steel Corporation
- National Tube Company
- Spang Chalfant Inc.

GENERAL PAINT CORPORATION
HILL, HUBBELL & CO. • Division • Cleveland, Ohio
• EXPORT OFFICE SAN FRANCISCO, CALIFORNIA, U. S. A. •

San Joaquin Chapter A.P.I. Meets

The regular meeting of the San Joaquin Valley Chapter of the American Petroleum Institute was held at the Standard 11-C meeting hall, Taft, on January 19. The meeting was called to order by Chairman George O. Suman with 115 members and guests present.

The secretary announced the appointment of Don Drenk, D + B Division, Emsco Derrick and Equipment Company, Taft, as steward, and Ken McNamara and Jack Crooker, Standard Oil Company of California, Taft, as technicians.

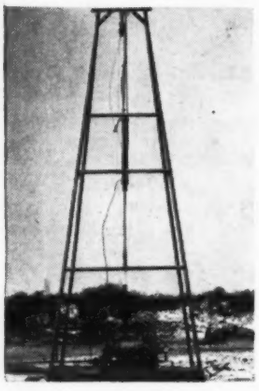
Chairman Suman gave a digest of the report of the meeting of the Central Committee on District Activities held in Chicago on November 10, 1942. Chairman Suman introduced the vice-chairman in charge of programs, C. H. Montgomery, who offered the following program:

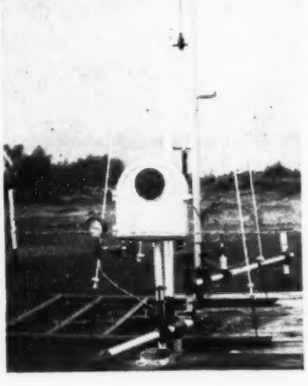
"The Outlook for New Oil Fields in California and a Review of Recent Discoveries," by George Kribbs, Bankline Oil Company.

"Egypt—From Cairo to the Quattara Depression," by Joe Demming, The Texas Company.

"Industries of a Fruitful Land," a moving picture by courtesy of J. R. Minner and the Pacific Gas and Electric Company. Projectionist Frank Ternan, and equipment loaned by Elliott's office of Taft Union High School.

NIXON *Surface Control*
GAS-LIFT SYSTEM
assures
PROFITABLE PRODUCTION





So extensive are the economies of the Nixon Gas-Lift, that savings on production begin with its installation. Cost of the Nixon Gas-Lift; Cost of transportation and installation; Cost of operation and maintenance . . . are but a fraction of the cost of conventional pumping units.

Production is surface controlled. Large or small volumes handled by this system.

Nixon Gas-Lift Systems are available for immediate installation. Their manufacture requires only an extremely small amount of essential materials.

Hundreds of installations have proven its economy and efficiency. Ask a Nixon Gas-Lift engineer to show you case histories of "Profitable Production" with the Nixon Surface Control Gas-Lift System. Write your nearest Wilson Supply Co., store or sales office.

WILSON SUPPLY COMPANY
1412 MAURY STREET — HOUSTON, TEXAS

SALES OFFICES:
Tulsa, Oklahoma; Dallas, Texas
LOS ANGELES: Western Pressure Control Co., 5700 Santa Fe Avenue.
TRINIDAD, B.W.I.: Neal Massey Engineering Corporation.

BRANCH STORES:
TEXAS—Gladewater, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi.
LOUISIANA—Lake Charles, New Iberia, Harvey, Shreveport.

Natural Gasoline Men to Have War Products Convention

The twenty-second annual convention of the Natural Gasoline Association of America is to be primarily concerned with the problems of stimulating production of products needed in the war effort, according to Ray E. Miller, Hanlon-Buchanan, Inc., Tulsa, Oklahoma, president of the association. The convention dates, which have just been announced, are April 14 to 16 in the Baker Hotel, Dallas.

In speaking about the meeting, Miller stated the N.G.A.A. board of directors had given serious consideration to Government requests for trade groups to forego or curtail their usual conventions this year. "We appreciate the reasons which prompt this request," he said, "but we believe the type of discussions planned for this convention are in the national interest since they will aid the industry to correlate its efforts in the war program and thereby increase its effectiveness. The natural gasoline and distillate industries are large producers of the prime raw materials used in manufacturing high octane aviation fuels, rubber and chemicals and a meeting of the executives and technical men of these industries to discuss the problems involved will have a definite stimulus to their production."

Although the dates announced cover a period of three days, the program is to be so arranged as to avoid as much train congestion as possible. Only committee meetings and reports are scheduled for Wednesday the first day. Thursday is to be full with morning, afternoon and evening sessions and the convention will close Friday noon. Announcement to this effect was made by James W. Vaiden, vice-president, Skelly Oil Company, Tulsa, chairman of the Program Committee. Other members of the Program Committee include: John B. Atkins, The Parade Company, Shreveport, Louisiana; Paul C. Coffin, Shamrock Oil and Gas Company, Amarillo, Texas; Howard Felt, Warren Petroleum Corporation, Tulsa; Dr. O. L. Roberts, Atlantic Refining Company, Philadelphia, Pennsylvania; Harry Wheeldon, Lone Star Gasoline Company, Dallas, Texas, and C. R. Williams, The Chicago Corporation, Corpus Christi, Texas.

William F. Lowe, N.G.A.A. secretary, urges that all who plan to attend these sessions make their room reservations direct with the Baker Hotel as soon as possible.

General Advance In Crude Oil Prices Ruled Unjustified

Citing the United States Tariff Commission's exhaustive survey of crude petroleum prices and costs, the Office of Price Administration announced February 1 that a general advance in crude oil prices for the nation's oil production is not justified at this time.

Such an increase, it was pointed out, would add heavily to the consumer's fuel bill and dangerously threaten price control, as oil is a basic commodity in the domestic, industrial, and military economy.

The Tariff Commission analysis, it was stated, indicates that continuation of present crude prices —including the special price increases already granted in some fields and for various areas— will enable the majority of producers to absorb any increases in production costs and maintain a margin of profit that must be considered adequate in wartime.

There will, it was explained, be exceptions, which is true at any time, but to raise all prices to relieve the exceptional producer would disrupt the entire price structure of the petroleum industry and would not be justified by any evidence that has been put forward to date.

Such an increase, it was pointed out at OPA, would necessarily be reflected in the cost of living and the burden of wartime costs.

This attitude toward a general increase in crude oil prices, OPA petroleum officials stressed, does not mean that the door has been closed against consideration of local, regional, or area price problems arising from abnormalities, undue hardship arising from oil shortages, and uneconomic price structures.

OPA has maintained and will maintain, it was emphasized, a sympathetic and open-door policy to any and all petitions for price adjustment especially where abnormal conditions have resulted in hardship and uneconomic operation at present price levels. Such price adjustments were expected and are inevitable, OPA officials said, but because the widespread publicity attending the gathering pressure for a substantial increase in crude oil prices coincides with the government's own report of its investigation through the Tariff Commission into crude oil prices and costs, its presentation to the public and to industry is deemed timely.

The problem of current exploration of finding costs has been before the interested Federal agencies handling petroleum matters for some time. These costs must be separated from direct crude production costs, OPA said, and investigations are now in progress by the various agencies to develop a solution for the problem but OPA has indicated in the past that it cannot properly be solved by a nation-wide increase in price, which would impose extraordinary price increases upon the consumer.

CLARIFICATION CRUDE OIL PRICES

To achieve greater uniformity in establishing maximum crude petroleum prices at October, 1941, levels, the Office of Price Administration clarified, January 28, its formula for crude oil ceilings in the following respects:

1. Maximum prices for crude petroleum are intended to reflect actual market conditions within a given oil pool, or at such other points where the oil was sold, during the base price period of October, 1941. Some sales of that period were made under long-term contracts that did not necessarily reflect current market prices.

2. Price paid at the receiving tank or at some other point under a contract, which was in effect prior to the base price period, shall not be considered in determining ceilings under price control unless the contract price actually reflected October, 1941, marketing conditions for the particular pool involved.

In general, Revised Price Schedule No. 88— Petroleum and Petroleum Products — provides crude oil ceiling shall be those posted for an oil pool during the base price period, or the price paid at the receiving tank during that period. Amendment 63 to that schedule seeks to eliminate inequities arising from factors that may have controlled sales at a point below the current October, 1941, market.

The amendment further provides that the maximum price of crude oil purchased at a point other than the receiving tanks shall be at no greater differential than prevailed at the same point in October, 1941. Such a differential shall not be considered, however, if it fails to reflect the current market conditions of that month.

The amendment authorizes the buyer and seller to establish a temporary differential for a sale at a point other than the receiving tank, subject to disapproval by OPA, when a maximum price cannot be otherwise determined under the provisions of the schedule. Its principal effect will be felt in small pools whose production was sold under long-term contracts that did not take into consideration progressive increases in market prices, cost of production, or changing market conditions.

PRIORITY ASSISTANCE FOR MATERIALS ABROAD

An amendment of WPB Priorities Regulation 9 and revocation of Preference Rating Order P-98-d, both of which affected oil operators applying for priority assistance for materials sent to foreign countries, were ordered January 20 by the War Production Board upon the recommendation of the Petroleum Administration for War.

Under an amendment to WPB Priorities Regulation 9, oil operators now will use only Form PD-311 or PD-311C, whichever is applicable, to apply for priority assistance for materials to be used in foreign countries as maintenance, repair, and operating supplies and production equipment. Previously, in some cases it was possible for operators to obtain priority assistance by filing forms PD-1A and PD-3A.

Deputy Petroleum Administrator Ralph K. Davies said that by requiring all foreign operators to use Form PD-311 or PD-311C the procedure in obtaining priority assistance will be simplified.

Ratings will be assigned by WPB, or in the case of some products, by BEW, acting under General Exports Order M-148, as amended January 20.

To apply ratings thus assigned, endorsement of a purchase order with the certification that the operator has received an export license, a statement of export clearance, or a statement of authority to export is sufficient, whether the rating is assigned by WPB or BEW.

NEW NATURAL GAS WELLS KANSAS, OKLAHOMA PANHANDLE BANNED

The use of material for the drilling of new natural gas wells in the Hugoton field in Southwest Kansas and the Oklahoma Panhandle was banned January 23, by Petroleum Administrative Order No. 6, issued by the office of Petroleum Administrator for War Harold L. Ickes.

Effective immediately, the order prohibits the use of any materials to drill, complete, or provide additions to any well in any discovered or undiscovered natural gas field in Kearney, Finny,

FOUR TESTED WAYS to make Brake Lining Last Longer

The suggestions given at the right are presented by Johns-Manville as proved methods of conserving drilling equipment, and of increasing the life and efficiency of brake linings.

1. **Check brake and clutch adjustment regularly** . . . to guard against unequal wear on friction materials.
2. **Don't box-in brakes and clutches** . . . Assure maximum heat dissipation by providing increased air flow.
3. **True up rims whenever scored or heat-checked,** to prevent unusually rapid wear of linings and facings.
4. **Don't try to control friction by using oil, clay or other such substances** on linings.

For further suggestions and for tips on how to secure longer life and higher efficiency from Packings, Insulations, Roofings and Refractory Cements, write for the new J-M Manual, "101 Suggested Good Operating Practices." Johns-Manville, 22 East 40th Street, New York, N.Y.

And for maximum efficiency, start rigs right with*

JM PRODUCTS

Johns-Manville 420 ROTARY LINING

*Write for Catalog FN-10A

Grant, Haskell, Morton, Stevens, or Seward counties in Kansas or in Texas County, Oklahoma.

The order does not affect the use of materials on any well drilled under a specific exception granted after September 3, 1942, in accordance with the terms of Conversation Order M-68, as amended.

PAW may issue exceptions to the present ban on the use of materials in the field. Applications to use material to drill, complete, or provide additions to any well must be made by filing a letter in quadruplicate or by sending a telegram to the Director of the Natural Gas and Natural Gasoline Division, Petroleum Administration for War, South Interior Building, Washington, D. C., Ref: PAO 6.

Explaining the need for the order, Deputy Petroleum Administrator Ralph K. Davies said:

"Some 330 wells now are producing natural gas in the Hugoton field. They are keeping available natural gas pipe lines loaded to capacity.

"Until new natural gas pipe lines are constructed, it will not be in the interest of the war program to use scarce materials for the drilling of wells whose production cannot be made available to consumers because of lack of transportation facilities."

The natural gas wells in the Hugoton field serve such areas as eastern Kansas, Omaha, Minneapolis, St. Paul, Detroit, and other Midwest sections.

P-98-b AMENDED—HIGHER RATINGS ASSIGNED

Higher preference ratings for materials required by the oil industry for certain operations were assigned January 30 by the War Production Board under Preference Rating Order P-98-b, which was amended upon the recommendation of the Office of Petroleum Administration for War.

Preference ratings of AA-1 have now been assigned for materials to be delivered to petroleum industry operators for use in maintenance and repair operations or for use in alterations. Previously, these materials were assigned a rating of AA-2X or lower.

The amended P-98-b Order also provides that in cases of actual breakdowns, an operator can expedite delivery of materials by obtaining the countersignature of the appropriate district office, if the item to be purchased costs less than $500.

In all other instances—including actual breakdowns where an item costs $500 or more—an operator cannot apply an AA-1 rating until he has received approval from the WPB Director General for Operations. Applications for such approval should be addressed to the Petroleum Administration for War, South Interior Building, Washington, D. C., Reference: P-98-b.

Provided that an item costs less than $50 materials to be used in research laboratories may be obtained by applying a rating of AA-2X or lower without a countersignature from a district office or approval from the Washington offices of either PAW or WPB.

The amended order also clarifies the fact that an operator requesting approval to apply various preference ratings no longer is required to name a supplier or suppliers from whom he expects to obtain the material. This means that an operator has greater freedom, once the rating is granted, to purchase his supplies wherever he wishes.

NELSON LETTER ON PAW RESPONSIBILITY

Chairman Donald M. Nelson, in a letter to Petroleum Administrator for War Harold L. Ickes, has outlined the division of responsibility between WPB and PAW in connection with actions affecting the petroleum industry.

A WPB release states:

"Mr. Nelson's letter, which was confirmed by Mr. Ickes, dealt with the relationship of the two agencies under Executive Order 9276, which delegated to Mr. Ickes authority to determine policies and take actions relating to the industry.

"The letter was based on 'our mutual understanding,' Nelson wrote. It stated the relationship as follows:

"1. Under Executive Order 9276, the Administrator will issue directives and orders to the petroleum industry relating to the production, refining, treating, storage, shipment, receipt and distribution within the industry of petroleum, petroleum products, or associated hydrocarbons as defined in the order. To avoid confusion with WPB actions, the Administrator's actions will be designated as 'petroleum directives' or 'petroleum administrative orders.'

"2. The Administrator also may take action, to the extent specified in the order, concerning the distribution within the industry of other products or material, including the granting or denial of priority, allocation or preference rating assistance to the industry. Such actions will be subject to program determinations and other directions of the WPB chairman and will be issued in the name of WPB's Director General for Operations. The Administrator's signature will appear on such documents so that the industry will be able to distinguish between actions originating in WPB and those originating with PAW.

"3. The Administrator will give WPB reasonable advance notice and opportunity for consultation before taking any of the actions outlined above, excepting in case of an emergency, by mutual agreement with certain WPB officers, or in cases where the proposed action will not affect more than two members of the industry, provided the members do not represent the majority of the particular branch of the industry affected.

"4. WPB will continue to give the Office of Petroleum Co-ordinator for War reasonable notice and opportunity to be heard concerning all actions which might affect the petroleum industry, subject to the same exceptions as those set forth above.

"5. The Administrator will give WPB five days' notice before taking action affecting products or hydrocarbons not deemed to come within the definition of petroleum products and associated hydrocarbons contained in the Executive Order.

"6. The Administrator will provide the means for enforcing all 'petroleum directives' or 'petroleum administrative orders.'

"7. As soon as possible, WPB orders which come within the provisions of paragraph 1 above will be reissued by the Administrator, and the WPB orders will be revoked. This includes L-70, regulating shipments of motor fuel, and all orders in the M-68 series, which deal with petroleum production and marketing material and conservation of petroleum material.

"Procedures for giving the notices referred to in paragraphs 3, 4, and 5 above will be worked out between PAW and the Deputy Director General for Distribution of WPB. Additional procedures for the presentation of the petroleum industry's requirements to WPB are still under discussion, and will be determined as soon as possible."

ELECTRIC MOTORS, GENERATORS REQUIRE AA-5

Purchase orders for electric motors and generators shall not be accepted by manufacturers or dealers unless they bear preference ratings of AA-5 or higher under the terms of Conservation Order L-221 as amended by the Director General for Operations.

The amended order thus provides a rating "floor" on orders for both electric motors and generators. No other changes are made in L-221 as amended December 8, 1942.

☆☆☆

Simple, Precise, Strong...

3 MUSTS FOR FULL ROLLER BEARINGS

Americans are *simple* . . . because simplicity of design assures long life, less trouble-shooting, easier replacement. AMERICANS are *precise* . . . for precision in full roller bearings is essential to smooth, quiet, flawless operation of heavy equipment. AMERICANS are *strong* . . . as the success of every other factor depends upon full strength to meet the demands of the service involved, with an ample margin of safety.

Our engineers will welcome your problems.

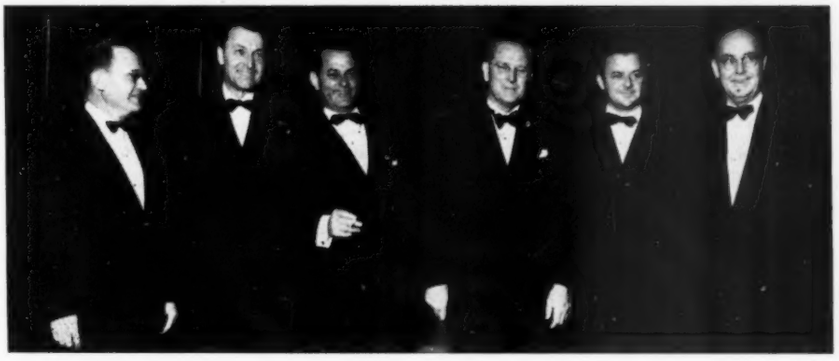
AMERICAN ROLLER BEARING CO.
PITTSBURGH PENNSYLVANIA
Pacific Coast Office: 1718 S. Flower St. Los Angeles, Calif.

AMERICAN
Heavy-Duty ROLLER BEARINGS

Houston Nomads Hold Third Annual Meeting

The Houston Chapter of Nomads held its Third Annual Meeting on January 29, 1943, at the Houston Club.

Approximately 140 members and guests attended and went away feeling that it was one of the most successful "Annuals" to date.



Right—New officers installed at the Houston Chapter of Nomads, from left to right: W. A. Davis, sergeant-at-arms; H. J. Craig, vice-president; C. E. Richards, assistant sergeant-at-arms; Gordon Richmond, president and regent; W. J. Nutto, secretary and treasurer, and Ray L. Dudley, regent. Carl Vogt, newly elected assistant secretary and treasurer, was not present

Music for dancing during and after dinner was provided by a popular band, which also supplied the music for the floor show.

Favors in the form of defense stamp corsages were given to all ladies present.

New officers were elected to serve during 1943. These included: Ray L. Dudley, regent; Gordon Richmond, regent and president; H. J. Craig, vice-president; W. J. Nutto, secretary and treasurer; Carl Vogt, assistant secretary and treasurer; W. A. Davis, sergeant-at-arms, and C. E. Richards, assistant sergeant-at-arms.

C. A. Meyer of National Supply Passes Away

The National Supply Company lost one of its veteran executives on January 15 in the death of Charles A. Meyer, treasurer, who passed away at his home in Pittsburgh, Pennsylvania, at the age of 59 after an illness of two months duration.

CHAS. A. MEYER

Meyer was affiliated with the Fairbanks-Morse organization prior to joining The National Supply Company upon the retirement of Treasurer Charles W. Clapp in 1923.

In This—The Great Emergency—

CLEVELANDS

As Always—Are Coming Through!

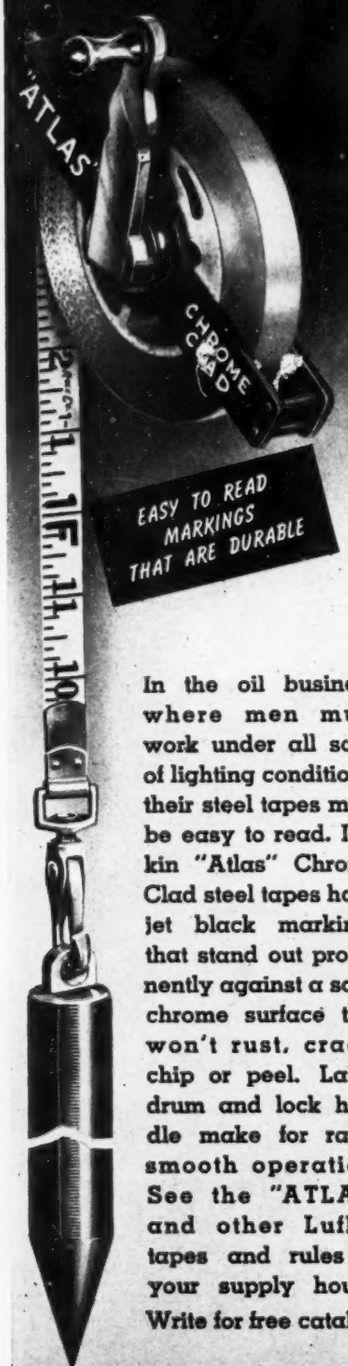
When there is ditch to dig.... or fill....
You'll always be glad you bought a

"CLEVELAND"

Keep them in fighting trim by regular attention to maintenance and lubrication.

THE CLEVELAND TRENCHER COMPANY
20100 ST. CLAIR AVE. "Pioneer of the Small Trencher" CLEVELAND, OHIO
"CLEVELANDS" Save More... Because they Do More

"ATLAS"
CHROME CLAD
STEEL TAPES



In the oil business where men must work under all sorts of lighting conditions, their steel tapes must be easy to read. Lufkin "Atlas" Chrome Clad steel tapes have jet black markings that stand out prominently against a satin chrome surface that won't rust, crack, chip or peel. Large drum and lock handle make for rapid smooth operation. See the "ATLAS" and other Lufkin tapes and rules at your supply house. Write for free catalog.

LUFKIN
SAGINAW, MICHIGAN • New York City
TAPES · RULES · PRECISION TOOLS

Pump Officials

In the accompanying photograph are A. J. M. Baker (left), general manager of the Crocker-Wheeler Electric Manufacturing Company Division of Joshua Hendy Iron Works; Charles E. Moore, president, Joshua Hendy Iron Works, and George A. McKenna, general manager of the Pomona-Westco Pump Company Division.

Recently Joshua Hendy Iron Works purchased the Pomona Pump Company, its subsidiary the Westco Pump Division, and the Crocker-Wheeler Electric Manufacturing Company.

W. C. Norris, Tulsa, Awarded Army-Navy "E"

The first Tulsa manufacturer to receive the coveted Army-Navy "E" award was W. C. Norris, Manufacturer, Inc., whose 700 employees received "E" pins as the pennant was presented on January 26. In the accompanying picture, holding the flag as it was being raised, is Col. Merle H. Davis, district chief, St. Louis Ordnance District, U. S. Army, who presented the flag; W. C. Norris; Capt. J. F. Donelson, U.S.N., Naval Training School, Norman, Oklahoma, who presented the "E" pins; Joe Eustice, assistant general manager, and sales manager of W. C. Norris; W. G. Skelly, president of Skelly Oil Company, master of ceremonies; Lieut. Commander T. A. Nichols, U.S.N., public relations department, Oklahoma City, and Don S. Bowers, vice-president and general manager of W. C. Norris.

Haubegger to Houston For Republic Steel

The appointment of E. E. Haubegger as district sales manager for Republic Steel Corporation in Houston, Texas, has been announced by N. J. Clarke, vice-president in charge of sales.

Prior to joining the Houston sales force in 1936, Haubegger was for seven years assistant district sales manager for Republic Supply Company in the same city. He became assistant district manager for Republic Steel in 1940.

Haubegger succeeds Gordon F. Hess who was recently named district sales manager for Republic in Detroit.

Prior to going to Houston Hess was assistant manager of sales of Republic's Alloy Steel Division. He entered the steel business in 1917 in the metallurgical department of the Central Steel Company, which later became a part of Central Alloy and in 1930 was incorporated in Republic.

Tulsa Nomads Elect Officers

Paul E. Fitzgerald, of Dowell Incorporated, Tulsa, Oklahoma, was elected president of the Tulsa Chapter of Nomads at the annual dinner and meeting held January 28. Other officers elected

P. E. FITZGERALD

were H. M. Cosgrove, executive manager of the Purchasing Agents Association of Tulsa, vice-president; Shep Miers, vice-president of the Southwest Supply Company, secretary and treasurer; G. W. Walton, sales manager of Unit Rig and Equipment Company, and C. O. Willson, editor of *The Oil and Gas Journal*, regents. Mrs. Ruth Sheldon Knowles, of the Petroleum Administration for War, was the principal speaker at the annual dinner.

Every Minute Saved in Maintenance . . . Means More Productive Hours

And these husky "King-clip" valves are doing just that . . . saving those precious minutes that add up to more productive time. With "King-clips" on the job, maintenance is cut to a minimum . . . users are assured of a practically permanent installation, free from the hundred-and-one "valve headaches".

"King-clip" Valves are doing their part in another respect, too . . . in conserving critical materials. Since only the working parts are made of bronze, these iron body valves use less copper, tin and other scarce materials than all-bronze valves, and they perform equally as well on many services.

And here's an important point . . . you are likely to get better deliveries on "King-clips" than on the scarcer all-bronze valves. The complete facilities of Lunkenheimer distributors are at your service. They'll go out to help you get the things you need.

●

Since virtually all materials used in the manufacture of valves are on the list of critical materials, valve users are urged to furnish the highest possible preference ratings and proper "end use" information on their orders. This will be of mutual helpfulness.

ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

Bronze, Iron and Steel Valves, 125 to 2500 lb. S. P. for all Industries; Boiler Mountings, Lubricating Devices, Aircraft Fittings

CHIKSAN
Ball Bearing
SWING JOINTS
SAVE

MANPOWER: Nothing to tighten or adjust. Less maintenance labor required.

VITAL MATERIALS: You can build your own flexible lines with **CHIKSAN** Swing Joints and pipe you have on hand—new or used.

REPLACEMENT COSTS: The CHIKSAN Swing Joints you install now will give years of service.

A JOINT FOR EVERY PURPOSE

☆ Over 500 different types, styles and sizes for rotation in 1, 2 and 3 planes, with full 360° turning on double rows of steel balls. Low Pressure Types for services ranging from vacuum to 300 lbs. W. P. and temperatures to 225° F. High Pressure Styles for services ranging from vacuum to 3000 lbs. W. P. and temperatures to 225° F. High Temperature Styles for steam service to 500 lbs. W.P. and temperatures to 700° F. Special packing sets for handling materials injurious to rubber and synthetic compounds.

COMPLETE ENGINEERING DATA ON REQUEST

CHIKSAN TOOL COMPANY
CHIKSAN
BALL BEARING SWING JOINTS for ALL PURPOSES
BREA, CALIFORNIA
ALL-STEEL ROTARY HOSE
CIRCULATING HEADS · MUD GUNS

New Standard Sizes and Weights for Seamless Tubular Goods

The Youngstown Sheet and Tube Company has issued a new price list dated February 1, 1943, covering Youngstown seamless oil country tubular goods consisting of new standard sizes and weights published by The American Petroleum Institute in their new specification, and as listed by The American Iron and Steel Institute in their latest specification. The technical men of these two groups in coöperation with the oil and gas producing industries and with the assistance of Mr. Joyce of the National Emergency Standard Specifications Division of the War Production Board adopted these new standard sizes and weights.

The old schedule contained a total of 331 items, whereas the new schedule contains but 188 items, showing a reduction of 143 items.

This standardization and elimination program has been under study by various interested agencies for more than two years, and the very substantial reduction in the number of sizes and weights will make it possible to operate with smaller inventories, thereby making additional steel available for other important war purposes. This elimination of sizes and weights and standardization effort will result in substantial savings in the cost of drilling oil and gas wells.

Technical Oil Tool Corp. Expands

Consolidating its three precision laboratories in one new, enlarged plant, Technical Oil Tool Corporation presents these scenes of production; Upper: One of the two parts production shops. Lower: Bay where precision parts of larger dimensions are made.

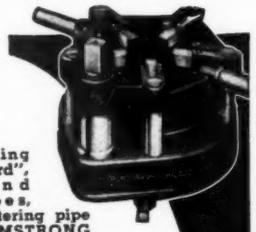
Marking a ten-fold increase in both personnel and manufacturing capacity, Technical Oil Tool Corporation, Ltd., has consolidated and expanded its facilities and is now converted to the manufacture of certain precision instruments necessary in war. One plant now houses the entire manufacturing organization that was formerly in three separate precision laboratories.

The new plant, at 1057 North La Brea Avenue, Los Angeles, California, is completely equipped for the designing, manufacturing, and assembling of precision devices on a quantity production basis.

A portion of the new plant and an experienced staff of technicians are allocated to the maintenance of Totco Recorders and equipment for controlled vertical drilling, and other products of the company used by the oil industry. According to J. B. Wood, president of Technical Oil Tool Corporation, Ltd., development work on several new technical devices is also being continued, although some delay has been occasioned by the readjustment of facilities to "Victory" work.

ARMSTRONG BROS.

RECEDING
TYPE
THREADERS



Improved Receding Threaders, "Standard", "Ratchet", and "Geared" Types, with new self-centering pipe holders and "ARMSTRONG BROS." Special Vanadium Tool Steel Chasers. The cutting teeth of these Chasers are carefully bibbed and "backed-off" for clearance; are hardened, drawn, tempered and tested. They are extra free cutting and are accurate in every respect. Each die segment is plainly marked with cutting size and number and is standard.

Write for Catalog C-39

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. Francisco Ave., Chicago, U. S. A.
Eastern Warehouse and Sales:
199 Lafayette St., New York

LONGER WEAR

Tips for users of RESPIRATORS

Want longer service and greater value from respirators? Then follow the few, simple suggestions Bullard offers in the new booklet, "How to Get Longer Service and Greater Value from Respirators." Over a quarter century of industrial safety experience backs these ideas. They're free! Send for your copy.

1B-15

E. D. BULLARD COMPANY
275 Eighth Street
San Francisco, California.
Everything BULLARD for Safety
Please send me illustrated booklet, "How to get Longer Service and Greater Value from Respirators."

Name _____
Company _____
Address _____
City _____ *State* _____ PE

NATIONWIDE SALES AND STOCKS

Directors Drilling Contractors Association Meet

A special meeting of the board of directors of the American Association of Oilwell Drilling Contractors was held at Dallas, Texas, January 29. Subjects included Manpower, Executive Order 9240, and Need for Coöperation with the PIWC, PAW, and other national agencies. The acute need for supplying the PAW with the drilling industry's material requirements resulted in a resolution authorizing the president to appoint district committees to determine such requirements.

Directors present were N. H. Wheless, J. E. Brantly, J. Zeppa, Howard P. Holmes, C. J. Davidson, George F. McQueen, Glenn A. Campbell, George P. Livermore, John J. Moran, W. C. Morris (Joe S. Morris), Wm. D. McBee, A. H. Rowan, W. J. O'Brien, and V. B. Mondy (Harry Bass).

A. J. Penick Gets Seabee Award of Merit

A. J. Penick, president of Oil Center Tool Company, Houston, Texas, was recently notified by Commander E. J. Spaulding, Officer in charge of Seabee Recruiting, Washington, D. C., to the effect that he had been selected to receive the Award of Merit of the Construction Battalions of the U. S. Navy.

A. J. PENICK

The certificate which bears the seal of the Navy Department states: "This certificate is awarded to Arthur J. Penick in acknowledgment of his patriotic contribution to the war effort in obtaining the enlistment of recruits for service in the Construction Battalions of the United States Navy."

(Signed) BEN MORCELL,
Rear Admiral, Civil Engineering Corps, U. S. Navy,
Chief of the Bureau of Yards and Docks.

FOR THE DEFENSE OF DEMOCRACY
THE BEST IS NONE TOO GOOD

FRANCE PACKING
has a
"Ring of Distinction"

Imitated but never duplicated, the France ring is manufactured in three sections. The contacting faces form the lines of an equilateral triangle. As the ring is expanded or contracted, the sections must move in or out radially equal distances from the center of the rod to which the ring is fitted.

This fundamental mechanical principle accounts for the efficiency, trouble-free performance and extra-long life of France Metal Packing.

After years of service, when the rings have become worn to such an extent that the sections nearly butt together, further years of additional service can be obtained by cutting off the narrow points of the three sections where they form a part of the inner circumference of the ring. The spring then requires adjustment so that the sections are held to the rod with a slight tension.

For installation in engines, pumps and compressors—under all conditions of service, France Full-floating Metal Packing means true economy in the long run.

Permit France Engineers to analyze your packing requirements.

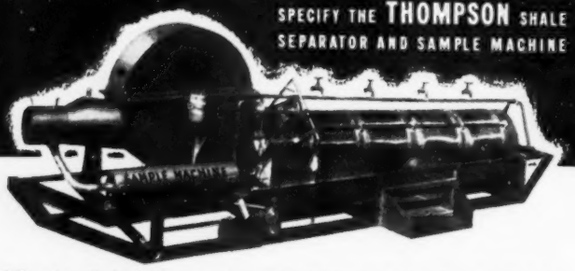
Write for Calatog M-3

Original FRANCE Metal Packing
Sold on approval
Satisfaction Guaranteed

THE FRANCE PACKING COMPANY
Tacony Philadelphia Penna.
Mid-Continent Representative:
MR. J. M. FULLER, 3725 West 7th Street
FORT WORTH, TEXAS

Original FRANCE METAL PACKING

FOR A REAL MUD CONDITIONING JOB
PLUS TRUE SAMPLES OF ALL CUTTINGS
SPECIFY THE THOMPSON SHALE SEPARATOR AND SAMPLE MACHINE



• Operates entirely from flow of mud...Sample Machine standard equipment...Made in three models to meet all drilling requirements. Guaranteed to give complete satisfaction

THOMPSON TOOL CO., INC.
Sold Through Supply Stores Everywhere
Phone 3521 Iowa Park, Texas

Saboteurs!

Increased product recovery with present cooling and condensing equipment is the demand. Scale, corrosion, and algae may be sabotaging this increased production.

Haering Glucosates control scale, corrosion, and algae on the water side and permit longer operation on steam. Our advisory service is a contribution we are proud to make without obligation to aviation gasoline plants and refineries. We will handle your problem complete and assure you results.

Write for free book on "Cooling Waters in Refineries"

HAERING WATER CONTROL
WE READ WATER

D. W. HAERING & CO., Inc.
GENERAL OFFICES:
205 West Wacker Drive Chicago, Illinois.

Everybody... Every Payday...
10% IN WAR BONDS

Along with increased war production goals go increased costs... extra billions which must be raised, and raised fast, to win this war. That means we must raise our sights all along the line, with every firm offering every American with a regular income the chance to buy more War Bonds. YOUR help is asked in encouraging employees to put at least 10 percent of their pay into War Bonds every pay day, through the Payroll Savings Plan.

U. S. WAR SAVINGS BONDS

McKean New President American Meter Company

At a recent meeting of the board of directors of American Meter Company, Norton McKean was elected president to fill the vacancy caused by the recent death of Francis H. Payne. McKean was formerly vice-president, treasurer, and general manager.

Elected vice-presidents were John C. Diehl, formerly chief engineer, with headquarters in Erie, Pennsylvania, and Arthur E. Norton, formerly manager of the company's factory in Boston. Diehl was also appointed to serve as manager of the Metric Metal Works Plant in Erie. A. McW. Wolfe, the assistant manager in Boston, was promoted to the managership of the Boston plant serving the New England area.

N. McKEAN

J. C. DIEHL

Calvin A. Nichols, controller and assistant treasurer, has been made acting treasurer.

Arthur F. Benson, formerly assistant chief engineer, was promoted to chief engineer of the company.

McKean first joined American Meter Company in July, 1913, in Boston, Massachusetts. He advanced to several positions of responsibility before he was made manager of the Albany plant in January, 1928. He has been a director

A. E. NORTON

A. F. BENSON

since April, 1932, became general manager in 1936, vice-president in 1937, and added the duties of treasurer in 1938. He is a member of the American Gas Association, the Association of Gas Appliance and Equipment Manufacturers, the New England Gas Association,

So Convenient to get — and to Use

SAND-BANUM

Automatically removes and prevents boiler scale and corrosion while your equipment operates.

"The Entirely Different Boiler and Engine Treatment"

Test it entirely at our risk for 30, 60 or 90 days. It *must* perform to your entire satisfaction or you owe us nothing. No money in advance—not even shipping charges. Send for your test material on this basis today.

AMERICAN SAND-BANUM COMPANY, Inc.

9 Rockefeller Plaza, New York City

Stocks carried by

WESTERN SAND-BANUM COMPANY
Houston, Texas **Fresno, California**

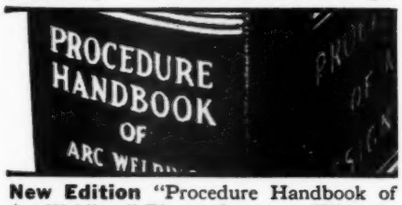
and at other convenient points including leading supply houses

Export Representatives

PETROLEUM MACHINERY CORP.
30 Rockefeller Plaza **New York City**

New Book on

ARC WELDING



New Edition "Procedure Handbook of Arc Welding." Bigger than ever. Wider in scope. Latest information on all phases of arc welding—the ace process of war production and key to progress and increased earning power in post-war era.

Authoritative. Recognized the world over as the "bible" on arc welding design and practice. Many thousands in use by welders, designers, engineers and shop managers. Standard text in hundreds of schools and colleges.

1308 pages • 1810 illustrations
Size 6" x 9" x 1¾"

A $5.00 Value for only $1.50 **post-paid**
($2.00 outside U. S.)

Order your copy today.
Mail order and check to
THE PETROLEUM ENGINEER
Box 1589, Dallas, Texas

New Jersey Gas Association, and Southern Gas Association.

John C. Diehl first became associated with American Meter Company in 1919, serving as engineer until 1929, when he was made chief engineer. He has been a director since 1934. He studied at Gettysburg College, graduated in 1905, with a degree of B.S., after which he took a course in civil engineering at Massachusetts Institute of Tech-

A. McW. WOLFE

R. O. BORDEN

nology, and graduated from M. I. T. in 1910, with a degree of S.B.

He is a member of the American Gas Association and of the Association of Gas Appliance and Equipment Manufacturers.

Arthur E. Norton first went with the American Meter Company in 1898 with the Nathaniel Tufts Meter Works in Boston. He was appointed manager in December, 1927, and elected a director of the corporation in 1932.

During his long period of service he has had charge of the manufacturing plant in Boston, and of the sales activities in the New England territory.

Arthur F. Benson joined the Metric Metal Works factory in January, 1930, as an engineer, and has successfully undertaken increasing responsibilities. Both in the development and manufacture of the company's measuring instruments, he has made valuable contributions. He attended Lehigh University 1911-1915, M. I. T. 1915-1917. Before joining American Meter Company, he was engaged in the marine engine business at Seattle, Washington, from 1920 to 1929.

Robert O. Borden, who has now been promoted to assistant manager, joined the engineering staff of the company at Erie in 1925, after his graduation from Lehigh University in Mechanical Engineering.

A. McW. Wolfe entered the employ of the company with the Maryland Meter Works in Baltimore in 1919.

Calvin A. Nichols joined the company in October, 1936, as assistant to the controller. He was appointed controller in 1937, and in addition had been assistant treasurer since 1939.

"BIG INCH" BRIDLED BY LUDLOW

Up from Texas, 300,000 barrels of "galloping petroleum" will reach Illinois daily on its way to Eastern refineries. The world's biggest oil pipeline—"Big Inch"—will carry this mighty flow of oil. To control and direct it, the world's most dependable valves were specified—rugged, efficient Ludlow Valves. Built for service far into the future, Ludlow Valves will assure the smooth, trouble-free performance that has made them the first choice in the toughest of assignments. Let Ludlow give you value in valves. Send for Catalog.

THE LUDLOW VALVE MFG. CO., INC.
TROY, NEW YORK

Construction features: Self-releasing 30° angle wedges and free-floating gates, self-adjusting to seats, afford smooth action, tight closure, long service regardless of frequency of use. Rings cleaned throughout stroke action. Gates are wedge-locked directly opposite ports and completely unwedged before raising. Ample tolerances provide free movement. Simple construction permits easy replacement of parts.

LUDLOW VALVES

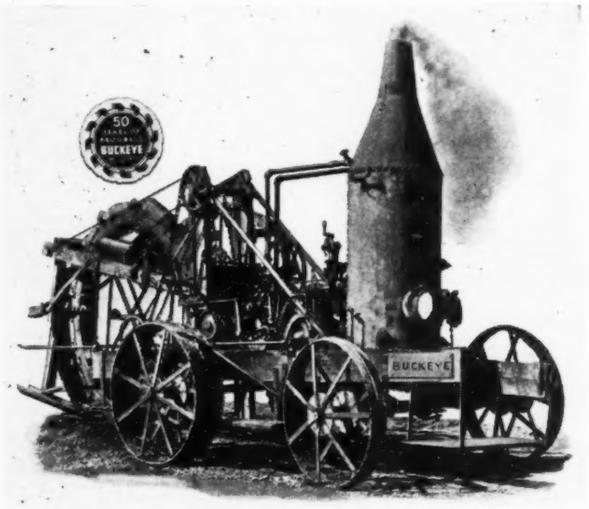
SINCE 1866 PV9

In These War Days
WE'RE DRILLING 'EM IN
under Pressure
...and GUIBERSON DRILLING
HEADS are Standard Equipment
"We're taking no chances these war days. Can't afford penetration of pay sands by mud and water. Can't afford unnecessary washing, swabbing, and bailing expense. We want production the moment the bit reaches the oil sand. That's why we're drilling in under pressure, using oil and gas or gas alone as the circulating column, and standardizing on the GUIBERSON DRILLING HEAD as our rotating pack-off. Works so well we call it 'Old Faithful.'" Write for particulars or see Page 919 of the Composite Catalog.
THE GUIBERSON CORPORATION
DALLAS, TEXAS
Export Representative: I. FRANK BROWN, 30 Rockefeller Plaza, New York City
Calif. Distributor: W. R. GUIBERSON CO. 723 East Gage Ave., Los Angeles, Calif.
Now supplying critical material to the Army, Navy, Marines, and Army Air Forces
GUIBERSON
LIFE EXTENSION SERVICE FOR OIL WELLS

Buckeye Traction Ditcher Celebrates Fiftieth Birthday

When the world's Columbian Exposition was preparing to open in Chicago 50 years ago, the first Buckeye ditcher was being completed in a tiny shop in Bowling Green, Ohio. James B. Hill, its designer and builder, thus became the founder of the Buckeye Traction Ditcher Company of Findlay, Ohio, one of the largest and best known manufacturers of trenching machinery in the world.

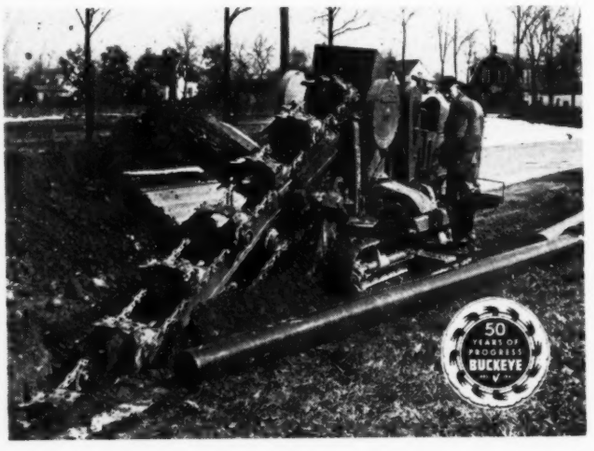
This forerunner of the modern Buckeye ditcher was of wheel type and was built without engineering drawings or



A steam-powered trencher—one of the first built by Buckeye

designs. All patterns were made of wood and most of them were carved out with a jackknife. This initial ditcher of half a century ago sold for $700 and netted Hill a salary of approximately $3 per day for his time and genius. Now established, five more machines were built in Bowling Green; and then, following a receivership, the patterns were loaded into a wagon and hauled to Deshler, Ohio, in 1898.

Five ditchers came off the Deshler assembly line, and then the plant was moved again — this time to Carey, Ohio. Twenty-five ditchers of various sizes were completed in Carey;



Buckeye Model 410 Boom Type Trencher

and then Buckeye took up the trail once more in 1901, this time with Findlay as its destination. The original Findlay site was on Fair Street. In 1908, the final move to Crystal Avenue, the location of the present plant, was made.

In its 50 years of progress, the applications of the Buckeye ditcher have been as varied as the factory locations. It was

originally built for laying drain tile on farms, but soon demonstrated its value for digging trench for many other purposes. With the growth of cross-country pipe lines, Buckeye came into its own for here was a job that could be performed in no other way.

After the development of the boom-type trencher about 15 years ago, power shovels and road building machinery were added to the now famous Buckeye line. Today, all items of Buckeye equipment are playing important roles in the war effort. Buckeye trenchers are widely used in draining the locations for many army camps, ordnance plants, and naval bases, for installing cable underground, for central heating plant conduits, and for water, sewage, lighting, and other encampment needs. Essential pipe lines are being laid over hundreds of miles in Buckeye-dug trench. Air bases and other war projects are using Buckeye R-B fine graders, spreader boxes, bulldozers, and other tractor equipment, and army engineers find many uses for scores of Buckeye shovels.

Hyatt Workers Accept "E" Award in the Name of Boys in Service

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey, has been awarded the Army-Navy "E" for exceptional achievement in the production of war equipment. The ceremony was broadcast on station WOR, Friday, January 22, from 3:45 to 4:15 p. m. Men and women workers of the plant accepted the award in the name of the hundreds of Hyatt boys and their buddies in service. They said, "To us this award means more than Government recognition of a job being well done. We see it as a compelling challenge to extend our efforts even more . . . to accelerate our current unprecedented output of vital precision bearings for war equipment."

Brewster Company Awarded Army-Navy "E"

The Brewster Company, Shreveport, Louisiana, has been awarded the Army-Navy "E" for excellence in war production. Presentation of the award flag was made in the Municipal Auditorium by Colonel E. C. Bomar, district chief, Birmingham Ordnance District, who was introduced by Hon. Samuel S. Caldwell, Mayor of Shreveport. A. Olin Price, vice-president and general manager of The Brewster Company, accepted the award in behalf of the company. Following him on the program Mrs. H. C. Brewster, president and treasurer of the company, addressed the gathering.

Presentation of award pins to employees was by Lt. Commander Kenneth C. Elliott. Herbert A. Harlan, production manager, and Earnest D. Garrett, chief engineer, accepted the pins in behalf of the employees. The program, which was held at 2:00 P. M., was broadcast over Radio Station KWKH.

Honor guests at the celebration were: Colonel E. C. Bomar, district chief, War Department, Birmingham Ordnance District; Colonel William B. Wright, commanding officer, Barksdale Field; Colonel Harry Weddington, executive officer, Barksdale Field; Lt. Colonel F. W. Hausmann, officer-in-charge, War Department, Birmingham Ordnance District, New Orleans Sub-Office; Lt. Colonel Stanley C. Shubart, commanding officer, Longhorn Ordnance Works, Marshall; Herbert Tutwiler, deputy district chief, War Department, Birmingham Ordnance District; Lt. Commander Kenneth C. Elliott, United States Navy; Major Daniel O. Todd, public relations officer, Barksdale Field; Major R. E. Russell, commanding officer, Louisiana Ordnance Plant; Major Fred H. Phillips, commanding officer, Lone Star Ordance Plant, Texarkana; Captain Bruce W. Franklin, assistant officer-in-charge, War Department, Birmingham Ordnance District, New Orleans Sub-Office; Captain Roy D. Hickman, adjutant, War Department, Birmingham Ordnance District, and First Lt. George R. Killam, Jr., War Department, Birmingham Ordnance District.

Young

JACKET WATER AND GAS COOLERS

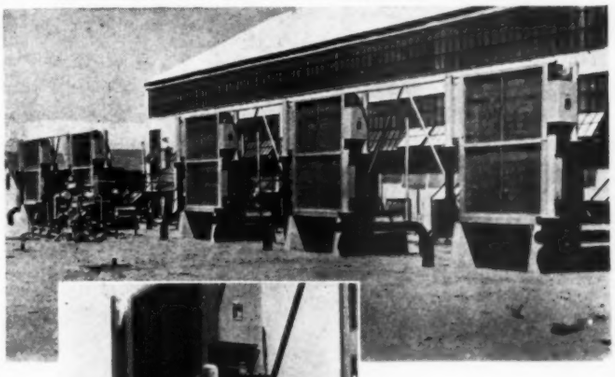
Save Building

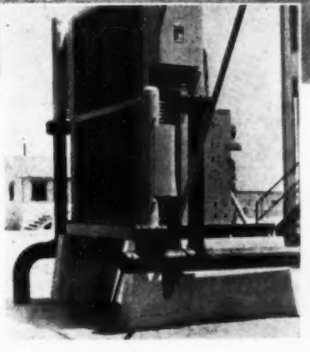
40 MILE PIPE LINE!

Faced with building a 40-mile pipe line for water to cool six 800 H.P. gas-engine compressor units and auxiliary engines, the El Paso Natural Gas Company decided on a test installation of YOUNG-HAPPY Engine Jacket Water Coolers. So satisfactory was the test that eleven YOUNG-HAPPY Coolers, each consisting of two large vertical radiator sections and a specially designed, highly efficient, variable pitch fan have been installed. Tests were run and five YOUNG-HAPPY Gas Coolers installed for cooling the gas after compression. YOUNG-HAPPY engineered cooling units fit ALL the requirements of the job. They save war-vital steel and cut power consumption costs. Let YOUNG solve *your* cooling problems.

YOUNG RADIATOR CO., Dept. 283B
RACINE, WIS., U.S.A.

Mid-Continent Distributor — The Happy Co., Tulsa, Okla.
Pacific Coast Distributor — A. R. Flournoy Co., Bell, Calif.





Five YOUNG-HAPPY single phase gas coolers.

★

One of a battery of eleven YOUNG-HAPPY Engine Jacket Water Coolers.

Young

Young ENGINEERING AND MANUFACTURING SERVICE SPECIALIZING IN HEAT TRANSFER PRODUCTS

HEAT TRANSFER PRODUCTS

OIL COOLERS • GAS, GASOLINE, DIESEL ENGINE COOLING RADIATORS • INTERCOOLERS • HEAT EXCHANGERS • ENGINE JACKET WATER COOLERS • UNIT HEATERS • CONVECTORS • CONDENSORS • EVAPORATORS • AIR CONDITIONING UNITS • HEATING COILS • COOLING COILS

MAKE YOUR OWN CUTTING TOOLS

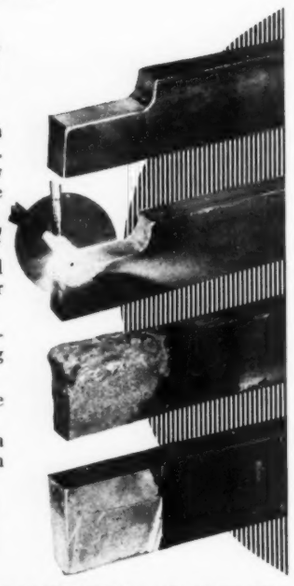
with the new

COLMONOY W C R ALLOYS

Bridge the gap between high speed steel and the carbides. Reclaim old, and make new cutting tools by welding. The process is simple.

To fabricate a typical tool

1. Undercut carbon steel shank, leaving a fillet for ease in welding.
2. Fill undercut, using ordinary hard facing welding procedure.
3. Hot wipe, to approximate shape, to save grinding.
4. Wet grind, using silicon carbide rough and finish wheels.



WRITE FOR LITERATURE

Immediate delivery of all grades of W C R Alloys at all branches.

WALL-COLMONOY CORP.

720 Fisher Bldg., Detroit, Mich.

Branches in New York City, Blasdell, N. Y., Chicago, Tulsa, Los Angeles, and in Canada

It Simmers Down To This . .

When a producer puts his mind on finding the most satisfactory pumping unit for a well, he's looking for three things: ECONOMY, DEPENDABILITY, EFFICIENCY. Producers who buy like that have made us the largest exclusive manufacturer of pumping equipment in the business. The men who own and operate 'em are very proud of the service record of JENSEN PUMPING UNITS.

JENSEN

BROTHERS MFG. CO.

Coffeyville, Kansas, U. S. A.

Export Office: 50 CHURCH STREET, NEW YORK CITY

TRADE LITERATURE

What to Write For

THE DESIGN AND METHOD of manufacture of Midwest Welding Fittings are discussed in detail in Bulletin WF-41, a copy of which will be sent by Midwest Piping and Supply Company, Inc., 1450 South Second Street, St. Louis, Missouri.

PAGE STEEL AND WIRE DIVISION, American Chain and Cable Company, Inc., has issued a helpful bulletin on how to save time and material welding stainless steel. It gives data on 42 commercial stainless steels—analyses, physical characteristics, reaction to heat and to cold working, specific welding electrodes to use with each, correct amperage and voltage, polarity, length of arc, direction of arc, starting the weld, preventing undercutting, etc. A copy of the bulletin will be sent upon request to the company at Monessen, Pennsylvania, or one can be procured from any distributor.

"COOLING WATERS IN REFINERIES" is the name of a booklet issued by D. W. Haering and Company, Inc., 205 West Wacker Drive, Chicago, Illinois. The publication discusses the treating of water for prevention of scale, corrosion, and algae.

BULLETIN GEA-3660, issued by General Electric Company, Schenectady, New York, gives a well-illustrated description of the 2300-volt control unit. The bulletin is free on request.

AIR REDUCTION SALES COMPANY, 60 East 42nd Street, New York, New York, is mailing free on request a folder containing a series of six shop bulletins or posters each stressing methods of eliminating waste of welding electrodes.

WHEELCO INSTRUMENTS COMPANY, Harrison and Peoria Streets, Chicago, Illinois, has issued five new bulletins describing its complete line of industrial indicating, recording, and control thermometers.

Bulletin G23-2, of 12 pages, discusses the operating principle of Wheelco thermometers, and gives information to aid the user in selecting the proper instrument for his application.

Bulletin G503-2 covers the company's recording control thermometer, whereas G603-2 is on the Wheelco indicating control thermometer.

Bulletin G303-2, two pages, describes and gives applications for the company's indicating thermometer, and Bulletin G403-2, two pages, covers its recording thermometer.

THE PART Clark engine-driven compressors and Pacific Pumps are performing in the synthetic rubber industry is illustrated and described in a bulletin issued jointly by Clark Bros. Co., Inc., Olean, New York, and Pacific Pump Works, Huntington Park, California.

IN FURTHER RECOGNITION of the great and growing contribution of maintenance to the war effort, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, has released another important maintenance manual—"Handbook for Wartime Care of Centrifugal Pumps." It is a part of a series that already includes books on the wartime care of motors and V-belts.

The new manual applies to all makes of pumps and contains no advertising. Copies can be obtained free of charge by writing the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

FOR LIGHTING, DISTRIBUTION, AND POWER CIRCUITS up to 600 amp., the complete line of Nofuze "De-ion" Circuit Breakers is described in a new 40-page booklet by Westinghouse Electric and Manufacturing Company.

"De-ion" breakers are available for panelboards, switchboards, built-in applications, individual mountings and separate enclosures. In this booklet principles of the "De-ion" arc quenching action are explained, and quick facts are given on design and operation of each breaker.

A copy of booklet DD-29-060 may be obtained from Department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

HOW THE STEAM-DETERGENT cleaning method is being utilized by the Nation's war and essential civilian industries to conserve manpower, reduce equipment down-time, and speed-up many different, commonly-recurring equipment maintenance tasks is the subject of a new, 24-page illustrated manual issued by Oakite Products, Inc., 22 Thames Street, New York, New York.

The manual, among other things, describes a recently improved type of steam gun that provides the triple combination of heat, mechanical force, and effective detergent action. This new development, known as the Oakite Solution-Lifting Steam Gun, may also be adapted for use in the removal of dirt, grease, grime, muck, and other deposits from such equipment as trucks, tractors, derricks, bubble caps, pumps, and heavy refinery equipment as well as for the salvage degreasing of parts too large for tank immersion cleaning and for stripping paint from exterior surfaces of small storage tanks.

KEUFFEL AND ESSER COMPANY, Hoboken, New Jersey, has issued the 1943 edition of the K & E Solar Ephemeris. This year the Ephemeris computations are based on Greenwich Civil Time instead of the Greenwich apparent noon as formerly. This is in accordance with the present U.S. Naval Observatory standard.

H. F. Stover Elected Director of National Association of Manufacturers

H. F. STOVER

The National Association of Manufacturers has just announced the election to its board of directors of Howard F. Stover of Tulsa, Oklahoma, who will serve on its board as National Director from Oklahoma.

Stover is secretary-treasurer of the Gaso Pump and Burner Manufacturing Company, Tulsa, Oklahoma, specialists in the manufacture of pipe-line pumps for the oil industry. He has been for many years active in organization activities in the industrial field, these activities including service as president of the Tulsa Purchasing Agents' Association, and as a National Director of the National Purchasing Agents' Association.

SPERRY-SUN

SPEED and ACCURACY

always when you use

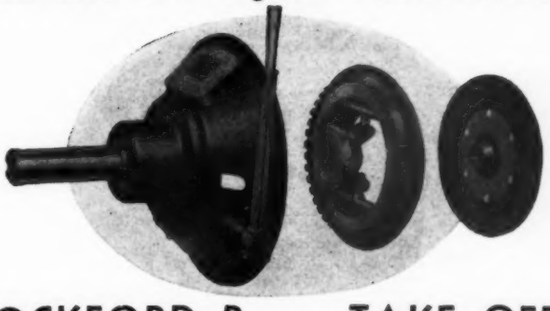
SPERRY-SUN

Throughout the world, over a period of years, Sperry-Sun Well Surveying Instruments and Technical Services have been among the producers' greatest aids in assuring fast, accurate and profitable drilling. Literature upon request.

SURWEL Clinograph	H-K Single Shot
SYFO Clinograph	M-M-O Bottom Hole Orientation
E-C Inclinometer	K-K Whipstock
H-K Inclinometer	Polar Core Orientation

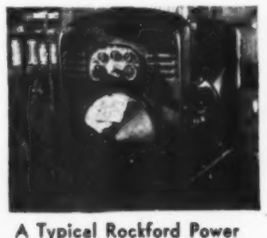
SPERRY-SUN WELL SURVEYING CO.
PHILADELPHIA, PA.
HOUSTON, TEXAS LONG BEACH, CALIF.

HARNESS *Your Engines'* HORSEPOWER



ROCKFORD *Power* TAKE-OFFS

The utility range of after-war engines will greatly help or hinder their competitive value in the struggle for peace-time volume. Our field engineers and factory engineering department are helping production engineers to increase the adaptability of their post-war models through providing for ROCKFORD Power TAKE-OFF applications. Our power transmission and control engineering facilities are at your disposal, without obligation.



A Typical Rockford Power Take-Off Application

Send for These Handy Bulletins on Power Transmission Control

Shows HOW the money-saving advantages of ROCKFORD Power TAKE-OFFS improve the efficiency and economy of power units. Gives capacities, dimensions, shaft sizes, types of bearings and other specifications.

Rockford Drilling Machine Division Borg-Warner Corporation
1303 Eighteenth Ave., Rockford, Illinois, U. S. A.

ENSIGN'S modern manufacturing facilities and more than 30 years of experience in producing efficient carburetion equipment are now all-out for Victory. Day and night, we are devoting practically our entire resources to help win the war.

But, although unable to provide our usual prompt service due to the war's demands, ENSIGN Carburetion Equipment is still available, and quick delivery of emergency parts is being maintained.

Now, as in the past, ENSIGN Carburetors for Natural Gas, Butane-Propane and Gasoline still lead the field for internal combustion engines of all types and sizes.

ENSIGN
CARBURETOR CO., LTD.
HUNTINGTON PARK • CALIFORNIA

Prepare, NOW, for post-war demands. Our competent engineering staff is at your service.

LOOK! LOOK!

To buyers and dismantlers of refineries, distilleries, breweries, and all kinds of industrial plants:

A large industrial consumer is constantly in the market for the following materials:

Steel valves and fittings, both flanged and screwed
Welding fittings
Tanks and pressure vessels
Recording instruments and gauges
Motors and electrical equipment
Pipe, seamless, lap, and continuous weld
Pumps and engines

Send stock lists of new or used materials to P. O. Drawer 465, Chicago, Illinois.

Conserve your equipment to bring Victory closer! And start with the best equipment you can get. For cable-system drilling and fishing, that means SPANG "Higher Standard" CABLE TOOLS. Available through supply stores.

SPANG & COMPANY
BUTLER, PA.

Book Reviews

Modern Oil Engine Practice, edited by E. Molloy. Published by Chemical Publishing Company, Brooklyn, New York. (1943). 636 pp. Price: $5.00.

This book provides an up-to-date survey of the various types of compression ignition or Diesel engines now available. Most of the book is devoted to stationary and marine types, but automobile, locomotive, and aero oil engines have also received adequate treatment.

The treatment covers the general principles of the two-stroke and four-stroke Diesel, including special types. Constructional details of all the leading makes are given, together with instructions on installation, operation, and maintenance.

Sections contributed by specialists in various branches include the following: Development of the Marine Oil Engine; The Development of the High Speed Diesel Engine; Recent Developments in Two-Stroke Compression Ignition Oil Engines; Shop and Type Testing of Diesel Engines; The Gas Diesel, and Torsional Vibration in Crankshafts.

•

New Commercial and Technical Dictionary, compiled by Antonio Perol Guerrero. Published by Chemical Publishing Company, Brooklyn, New York (1942). Price, $10.00.

This is a Spanish-English and English-Spanish dictionary in which are listed and defined more than 45,000 words. Each word has been carefully translated in accordance with the plan of the Royal Spanish Academy of Languages. It has been carefully checked in every way.

Compiled for the engineer and technician by a prominent Spanish engineer, there has been included all needed modern words referring to mechanics, mechanical engineering, aircraft, aviation, marine and naval terms, industrial chemistry, plastics, meteorology, etc. Each definition includes as much information as possible.

This dictionary contains conversion tables of weights and measures and monies alongside the literal translations.

Herrington a Director Army Ordnance Association

The Army Ordnance Association has paid tribute to one of the foremost exponents of American military preparedness in time of peace, as well as in time of war, by electing A. W. Herrington, chairman of the board of directors of the Marmon-Herrington Company, as a director of the national association.

Few men in the United States fit as well into the declared objective of the association; "to foster an understanding of industry's role in our national defense," for Herrington has been actively engaged in doing that very thing ever since the close of the first World War.

Bristol Publishes Binder of Bulletins

The Bristol Company, Waterbury, Connecticut, has published a series of bulletins covering automatic control and recording instruments for industrial furnaces, dryers, kilns, and ovens. These have been bound together in loose leaf form in order that additions and revisions may be easily inserted.

The binder set covers pyrometer recorders and controllers, thermometer recorders and controllers, humidity recorders and controllers, draft controllers, control valves and accessories.

The bulletins included are well illustrated with photographs, application drawings, and wiring diagrams, and the material included gives a wide selection of types and combinations to meet the needs of manufacturer or user.

MEETINGS

American Institute of Mining and Metallurgical Engineers, Annual Meeting—February 15, 16, 17, and 18, New York, New York.

California Natural Gasoline Association, Monthly Meeting—March 4, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

American Gas Association, War Conference—March 11 and 12, Detroit, Michigan.

American Association of Petroleum Geologists, Annual Meeting—April 7, 8, and 9, Fort Worth, Texas.

American Petroleum Institute, Division of Production, Eastern District—April 8 and 9, William Penn Hotel, Pittsburgh, Pennsylvania.

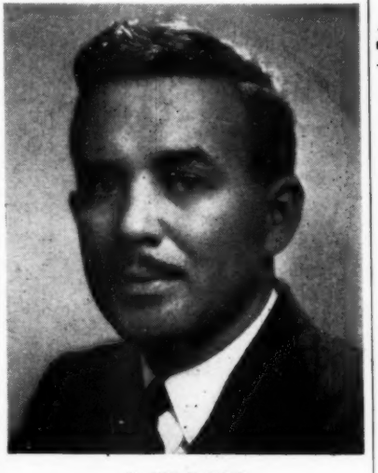
American Chemical Society, Annual Meeting—April 12, 13, 14, 15, and 16, Detroit, Michigan.

Natural Gasoline Association of America, Annual Meeting—April 14, 15, and 16, Dallas, Texas.

Petroleum Industry Electrical Association, Annual Meeting—May 5 and 6, Houston, Texas.

H. Lee Flood Manager New Orleans Territory for Crane Packing Company

H. Lee Flood, who has been Chief of the Materials Reclamation Section, Production Division, Petroleum Administration for War, resigned effective February 1, to join the staff of the Crane Packing Company as manager of the New Orleans, Louisiana, territory.



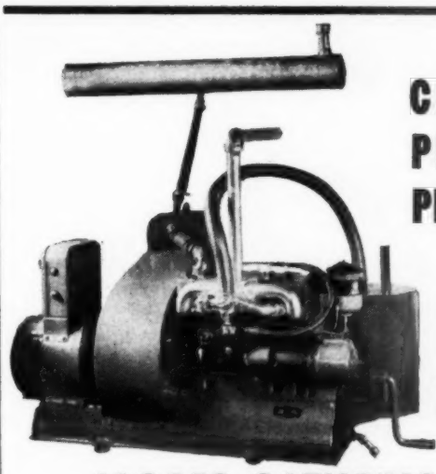
H. LEE FLOOD

Prior to going with the Office of Petroleum Administration for War January 1, 1942, Flood was associate editor of *The Petroleum Engineer*. He has had a diversified experience in the petroleum industry, having been an engineer with the Natural Gas Pipeline Company of America immediately before entering the publishing field, and was connected at various times with the Empire Oil and Refining Company, Shell Petroleum Corporation, Marland Oil Company of Oklahoma, Marland Oil Company of California, and the Empire Companies. He holds a degree in engineering from Stanford University, received in 1930.

Lucey Products Enlarges Texas Division

The Texas Division of Lucey Products Corporation has enlarged both its offices and personnel at Dallas and is now at 1206 Continental Building in that city, according to Eric G. Schroeder, vice-president, in charge.

Don D. Deason has been added as sales representative and Mrs. Adele C. Halpin as office secretary. Deason has spent many years in the equipment division of the refining and supply ends of the oil business and has been both in Texas and Oklahoma in the past. Mrs. Halpin likewise has served in the oil country supply business in her present capacity.



CATHODIC PIPE LINE PROTECTION

Vital to Victory

4-CYLINDER NEW IMPROVED 1943 MODEL

JACOBS CATHODIC UNIT

IMMEDIATE DELIVERY AT PRESENT

Operates on Natural Gas, Butane or Gasoline

MEETS any requirements from 1000 to 5000 watts, with ampere maximum 150, volts 10 to 40. Slow operating speed, 600 to 800 r.p.m., insures longer service. Other specifications—Fram oil filter, extra large 5-gallon oil crankcase reservoir, super-size special design oil type air cleaner, heavy duty Scintilla Magneto, extra heavy duty spark plugs, automatic radiator condenser (many months without added water) and automatic fuel shut-off insure peak operation and safety with minimum maintenance.

IMMEDIATE DELIVERY NOW. Anticipate your requirements; we cannot assure future delivery schedules and prices. *Write for Complete Literature and Prices.*

THE JACOBS WIND ELECTRIC COMPANY, INC.

Pipe Line Division

MINNEAPOLIS, MINNESOTA

America's Leading Manufacturer of Pipe Line Cathodic Plants

are in there Pitching for **VICTORY!**

In the manufacture of Wisconsin Heavy-Duty Air-Cooled Engines miracles of production have been achieved during the past twelve months . . . a volume that would have been considered impossible a year ago. This production, distributed through diversified industrial channels, has been dedicated almost 100% to Victory . . . and will continue to be so dedicated *for the duration.*

BUY BONDS FOR VICTORY

But we are working earnestly toward that "tomorrow" when Industry, as such, can again apply these fine engines to peacetime needs.

MOST POWER Per POUND

WISCONSIN MOTOR Corporation

MILWAUKEE, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

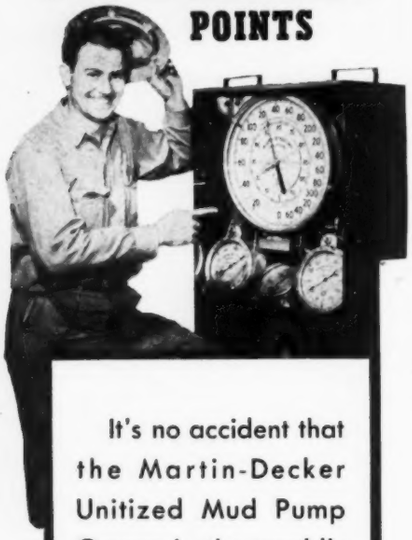
WRITE TO HARLEY SALES CO.

510 ATLAS BLDG., TULSA, OKLA.

H & H BLDG., HOUSTON, TEXAS

OIL FIELD DISTRIBUTOR FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

WEIGHT INDICATOR POINTS



It's no accident that the Martin-Decker Unitized Mud Pump Gauge is the world's finest, most sensitive and rugged instrument for measuring slush pump pressure. The oil industry's leading weight recording measurement and control concern devoted years of development work to combining a special indicating gauge, a patented diaphragm unit, and a built-in pulsation damper in one unitized instrument requiring no tubing or fittings for connection. And best of all, it can be moved from location to location on a moment's notice.

★

MARTIN-DECKER CORP.
LONG BEACH, CALIFORNIA
A. F. McQUISTON, BAKERSFIELD, CALIFORNIA
REED ROLLER BIT CO., HOUSTON, TEXAS

Index to Advertisers

Air Reduction Co. 15
Allis, Louis, Co. 49-50
American Cable Division of American Chain & Cable Company, Inc. Inside Back Cover
American Chain & Cable Company, Inc. Inside Back Cover, 13, 104, 124
American Iron & Machine Works Co. Back Cover
American Meter Company 9
American Roller Bearing Co. 142
American Sand-Banum Co., Inc. 149
Armstrong Bros. Tool Co. 147
Baash-Ross Tool Co. 25
Badger, E. B., & Sons Co. 43
Bantam Bearings Corp. 120
Baroid Sales Co. 4
Bethlehem Steel Company 135
Brewster Company, Inc. 71
Bullard, E. D., Co. 147
Cameron Iron Works Inside Front Cover
Cardwell Mfg. Co. 1
Case, J. I., Co. 137
Chapman Valve Mfg. Co., The 122
Chicago Bridge & Iron Co. 75
Chiksan Tool Company 146
Clark Bros. Co. 47
Cleveland Trencher Co. 143
Climax Engineering Co. 58-59
Continental Supply Co., The 103
Cook, C. Lee, Mfg. Co. 27
Cooper-Bessemer Corp. 38-39
Cummins Engine Co. 115
Dowell, Inc. 23
Electroweld Steel Corp. 61
Ensign Carburetor Co. 154
Fluid Packed Pump Co. 69
Fluor Corp., Ltd. 91
Foster Wheeler Corp. 56
France Packing Co. 147
Gaso Pump & Burner Mfg. Co. 77
General Electric Company 5
General Paint Corp. 139
Grizzly Manufacturing Co. 138
Gulberson Corp. 150
Haering, D. W., Co. 148
Halliburton Oil Well Cementing Company Front Cover
Hazard Wire Rope Division of American Chain & Cable Co., Inc. 104
Hill, Hubbell & Co. Division 139
Hughes Tool Co. 67
Hunt Tool Co. 28
Hyatt Bearings Division, General Motors Sales Corp. 132
Jacobs Wind Electric Co. 155
Jensen Bros. Mfg. Co. 152
Johns-Manville 141
Jones & Laughlin Steel Corp. 130
Jones, S. M., Co. 136
Kellogg, M. W., Co. 73
Lane-Wells Co. 62
Lincoln Electric Co. 83
Linde Air Products Co. 7
Ludlow Valve & Mfg. Co. 149
Lufkin Rule Co. 144
Lunkenheimer Co. 145
Macwhyte Company 3
Marley Company, Inc. 21
Martin-Decker Corp. 156
Merco Nordstrom Valve Co. 99-100
Midwest Piping & Supply Co., Inc. 107
Mission Mfg. Co. 81
National Supply Co., The 87
Oil Center Tool Co. 85
Otis Pressure Control, Inc. 17
Page Steel & Wire Division of American Chain & Cable Co., Inc. 124
Penberthy Injector Co. 19
Petro-Chem Development Co. 12
Petroleum Electric Power Association 110
Petroleum Rectifying Co. 89
Powell, Wm., Company 55
Pritchard, J. F., & Co. 126
Reading-Pratt & Cady Division of American Chain & Cable Co., Inc. 13
Reed Roller Bit Co. 64-65
Ridge Tool Co. 10
Rockford Drilling Machine Division 153
Spang Chalfant, Inc. 108
Spang & Company 154
Sperry-Sun Well Surveying Co. 153
Taylor Forge & Pipe Works 45
Thompson Tool Co., Inc. 148
Tretolite Co. 93
Tube-Turns, Inc. 95
Twin Disc Clutch Co. 128
Union Carbide & Carbon Corp. 7
Universal Atlas Cement Co. 2
U. S. Steel Corp. Subsidiaries 2
Vogt, Henry, Machine Co. 6
Wagner Electric Corp. 97
Wall-Colmonoy Corp. 152
Water Cooling Equipment Corp. 14
Wickwire Spencer Steel Co. 79
Wilson Supply Co. 140
Wisconsin Motor Corp. 155
Wyatt Metal & Boiler Works 116
Young Radiator Co. 151
Youngstown Sheet & Tube Co. 11